Social norms towards smoking and vaping
are they associated with smoking and vaping behaviours and policies across countries?

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Social Norms Towards Smoking and Vaping: Are They Associated with Smoking and Vaping Behaviours and Policies Across Countries?

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Abstract

Background: Tobacco control policies have been implemented in many countries to reduce the prevalence of smoking. Social norms have been theorised to be on the pathway between tobacco control policies and reductions in smoking prevalence. However, there has been little assessment of this pathway. There are also concerns that the increase in e-cigarette use (vaping) might renormalise smoking, particularly among youth, and undermine declines in smoking prevalence. Research is therefore needed to explore the associations between smoking and vaping norms, behaviours, and policies.

Aims: To assess, among youth, the associations between: *A1:* smoking norms and smoking behaviours, *A2:* vaping norms and vaping behaviours, *A3:* vaping norms and smoking behaviours, and smoking norms and vaping behaviours, *A4:* vaping initiation and smoking initiation, *A5:* smoking and vaping norms and harm perceptions of vaping and nicotine. To assess, among youth, and adult smokers, whether: *A6:* smoking norms correspond with tobacco control policies and smoking prevalence rates, *A7:* vaping norms correspond with vaping policies and vaping prevalence rates.

Methods: Six studies were used. *A1:* Systematic review [41 articles] and meta-analysis [17 articles]. *A1-4:* Longitudinal survey of British youth [N=1,152]. *A5:* Cross-sectional survey of British youth [N=2,103]. *A1-3&6-7:* Cross-sectional survey of youth in England, Canada, US [N=10,280]. *A6-7:* Cross-sectional survey of adult smokers in seven European countries [N=7,779]. *A6:* Longitudinal survey (2002-2015) of adult daily smokers in UK, Canada, US, Australia [N=23,831]. Norms were measured by assessing perceptions of how common (descriptive norms) and approved of (injunctive norms) smoking and vaping were among different social groups (family, close friends, peers, society).

Results: *A1:* Descriptive norms of close others (family, close friends) were strong, reliable predictors of youth smoking initiation, more so than the descriptive norms of wider social groups (peers, society) and injunctive norms. *A2:* Similar results were also found for associations between vaping norms and youth vaping behaviour. *A3:* There were also some associations between smoking norms and vaping behaviour, and vaping norms and smoking behaviour: in Britain, friend vaping was protective against smoking, while in the US, friend vaping was positively associated with smoking. *A4:* Among British youth, vaping was also found to predict smoking initiation, while smoking was found to predict vaping initiation. *A6:* Among youth, and adult smokers, smoking norms did not always correspond with tobacco control policies or smoking prevalence rates. Smoking was also not found to have become denormalised from 2002-2015 among adult daily smokers. *A7:* Vaping norms similarly did not always correspond with vaping policies or vaping prevalence rates.

Conclusions: The smoking and vaping behaviours of close others influenced youth smoking and vaping behaviours, respectively, more so than the behaviours of wider social groups and injunctive norms. Contrary to theorised, smoking and vaping norms often did not correspond with policies and prevalence rates. Denormalisation of smoking over time also did not occur among adult daily smokers. However, findings do suggest that vaping could have the potential to change norms towards smoking, and also smoking behaviour, among youth.

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As above, because this thesis incorporates publications, additional figures are provided in each publication but are not listed here.

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[1] East, K., Hitchman, S. C., Bakolis, I., Williams, S., Cheeseman, H., Arnott, D., & McNeill, A. (2018). The association between smoking and electronic cigarette use in a cohort of young people. *Journal of Adolescent Health, 62*(5), 539-547. doi: 10.1016/j.jadohealth.2017.11.301 (in Chapter 4)……………………..........…….72

[2] East, K., Brose, L. S., McNeill, A., Cheeseman, H., Arnott, D., & Hitchman, S. C. (2018). Harm perceptions of electronic cigarettes and nicotine: A nationally representative cross-sectional survey of young people in Great Britain. *Drug and Alcohol Dependence, 192*, 257-263. doi: 10.1016/j.drugalcdep.2018.08.016 (in Chapter 5)……………………………………………..………..………………………..…...88

[3] East, K., Hitchman, S., McNeill, A., Thrasher, J. F., & Hammond, D. (In Press). Social norms towards smoking and vaping and associations with product use among youth in England, Canada, and the US. *Drug and Alcohol Dependence* (in Chapter 6)……………………………………………..………..………………………..…...101

[4] East, K., Hitchman, S.C., McDermott, M., McNeill, A., Herbeć, A., Tountas, Y., Bécuwe, N., Demjén, T., Fu, M., Fernández, E., Mons, U., Trofor, A.C., Zatoński, W. Fong, G.T., & Vardavas, C., on behalf of the EUREST-PLUS consortium (2019). Social norms towards smoking and electronic cigarettes among adult smokers in seven European countries: Findings from the EUREST-PLUS ITC Europe Surveys. *Tobacco Induced Diseases, 16*(2). doi: 10.18332/tid/104417 (in Chapter 7)…...135

[5] East, K., Hitchman, S. C., McNeill, A., Ferguson, S., Yong, H. H., Cummings, M. K., Fong, G. T., & Borland, R. (in press). Trends in social norms towards smoking between 2002 and 2015 among daily smokers: Findings from the International Tobacco Control Four Country Survey (ITC 4C). *Nicotine and Tobacco Research*. doi: 10.1093/ntr/ntz179 (in Chapter 8)…………………………………..…………...156

[6] East, K., Hitchman, S. C., Bakolis, I., Williams, S., Cheeseman, H., Arnott, D., & McNeill, A. (2018). The authors reply. *Journal of Adolescent Health, 63*(1), 118-119. doi: 10.1016/j.jadohealth.2018.04.006 (in Appendix H)……………..………296

List of presentations

Harm perceptions of electronic cigarettes and nicotine in GB youth: are they associated with social norms? [Poster Presentation]. Society for the Study of Addiction (SSA) 2016 Annual Meeting, York (England), November 2016. *Poster available online, see [7].*

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Social norms towards smoking and e-cigarette use among youth and association with product use: Findings from England, Canada and the United States [Poster Presentation]. SRNT 2018 Europe Annual Meeting, Munich (Germany) September 2018. *Poster available online, see [12].*

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List of abbreviations

4C Survey	Four Country Survey
4CV Survey	Four Country Smoking and Vaping Survey
AOR	Adjusted Odds Ratio
ASH	Action on Smoking and Health
ASSIST	A Stop Smoking In Schools Trial
CAPI	Computer Assisted Personal Interviewing
CATI	Computer Assisted Telephone Interviewing
CI	Confidence Interval
CIHR	Canadian Institutes of Health Research
CRUK	Cancer Research UK
DK	Don't Know
EC	Electronic Cigarette
ESOMAR	European Society for Opinion and Marketing Research
EU	European Union
EUREST-PLUS	European Regulatory Science on Tobacco: Policy Implementation to Reduce Lung Disease
FCTC	Framework Convention on Tobacco Control
GB	Great Britain
GEE	Generalised Estimating equations
GOR	Government Office Region
HSI	Heaviness of Smoking Index
ISCED	International Standard Classification of Education
ITC Project	International Tobacco Control Policy Evaluation Project
MI	Multiple Imputation
NA	Not Applicable
NHS	National Health Service
NIHR	National Institute for Health Research
NOS	Newcastle-Ottawa Scale
NRT	Nicotine Replacement Therapy
NUTS	Nomenclature of Territorial Units for Statistics
OR	Odds Ratio
PRIME Theory	Plans, Responses, Impulses, Motives, Evaluations Theory
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
SD	Standard Deviation
SE	Standard Error
SPSS	Statistical Package for the Social Sciences
TNS	Taylor Nelson Sofres
TPD	Tobacco Products Directive
UK	United Kingdom
UKCTAS	UK Centre for Tobacco and Alcohol Studies
US	United States
W	Wave
WHO	World Health Organisation

Author name abbreviations

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AH	Aleksandra Herbeć
AM	Ann McNeill
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SW	Sarah Williams
TD	Tibor Demjén
UM	Ute Mons
WAZ	Witold A Zatoński
YT	Yannis Tountas

Structure and chronology of this thesis

This thesis is submitted as a thesis incorporating publications, an alternative formal route for PhD submissions recognised by King's College London.

The structure of this thesis is as follows:

Chapter 1: Introduction and review of the literature.

Chapter 2: Systematic review and meta-analysis.

Chapter 3 Methodology of the publications in Chapters 4-8.

Chapters 4-8: Presentation and discussion of five publications [1-5].

Chapter 9: Discussion.

Figure i shows the timeline of work undertaken for the studies included in this thesis.

Figure i. Timeline of studies included in this thesis.

PhD year 1 (2016-2017)	PhD year 2 (2017-2018)	PhD year 3 (2018-2019)
Chapter 2. Systematic Review and Meta-Analysis of Smoking Norms and Smoking Initiation Among Youth		Chapter 2. (Update)
Chapter 4. Smoking and Vaping Initiation and Norms Among British Youth		
Chapter 5. Smoking and Vaping Norms and Harm Perceptions of Vaping and Nicotine Among British Youth		
	Chapter 6. Smoking and Vaping Norms Among Youth Across England, Canada, US	
Chapter 7. Smoking and Vaping Norms Among Adult Smokers Across Europe		
	Chapter 8. Trends in Smoking Norms Over Time Among Daily Smokers Across UK, Canada, US, Australia	

Chapter 3 details the survey methodology used in Chapters 4-8 and is not included in this figure.

Previous work

This research builds on a Department of Health funded project that I worked on as a Research Assistant from 2015-2016 [15]. The project involved developing new measures of social norms towards smoking, nicotine use (including electronic cigarettes (e-cigarettes)), and the tobacco industry, for the purpose of monitoring how social norms might be changing in light of the introduction of e-cigarettes. These social norms measures were then added to several national and international surveys, which I analysed for the research in this thesis.

CHAPTER 1

Introduction and Literature Review

1.1. Tobacco smoking

Tobacco smoking is one of the leading public health threats worldwide [16, 17]. Smoking kills over eight million people per year globally and causes at least 15 types of cancer and chronic respiratory and cardiovascular diseases [17-19]. Tobacco smoke contains thousands of constituents, including nicotine [16, 20, 21]. While it is primarily the nicotine in tobacco which is addictive, the vast majority of toxicity comes from other constituents of tobacco smoke [20, 21]. The negative health effects of tobacco smoking have been known and publicised for over 50 years [18, 19]. Further, several tobacco control policies have been implemented in many countries with the aim of reducing the prevalence of smoking [22-25]. Smoking prevalence has also fallen over this period; for example, in Great Britain smoking has decreased from 45.6% in 1974 to 16.6% in 2018 [26].

1.2. Electronic cigarettes

Electronic cigarettes (e-cigarettes) are battery-powered devices that heat a liquid usually containing nicotine to produce an inhalable aerosol [27, 28]. E-cigarettes are a relatively new product compared to tobacco cigarettes, with the first e-cigarettes appearing on the market in Great Britain around 2006 [27]. Since e-cigarettes were introduced to the market, there has been a rapid increase in their awareness and use in several countries [29-35]. In 2018, 6.3% of British adults used e-cigarettes (vaped)[1] [36].

Although their long-term health effects are unknown, several public health bodies have concluded that e-cigarettes are less harmful than smoking [20, 27, 31, 37, 38]. This conclusion is based on what is currently known about e-cigarettes, including how they are used, contents (including nicotine), and level of exposure to toxicants and carcinogens [20, 27, 31, 37-44]. E-cigarettes can also help some smokers quit or reduce their smoking [27, 31, 38, 45, 46] and the results of a recent randomised controlled trial suggest that vaping is more effective than nicotine replacement therapies in helping smokers quit [47]. While the research is still evolving, overall e-cigarettes have the potential to reduce the health harms from smoking. Despite this, there are some concerns about vaping, specifically that the long-term effects of vaping are unknown, that vaping may attract new groups of youth into nicotine use and smoking, and that vaping might "renormalise" smoking [35, 48-56].

1.3. Rationale for this research

The implementation of comprehensive tobacco control policies alongside decreasing smoking prevalence in many countries has led to the assumption that smoking has become "denormalised" [55, 57]. Conceptual models and theories have also placed social norms on the pathway between the implementation of tobacco control policies and declines in smoking prevalence [58-62]. However, there has been little assessment of this pathway. There are also concerns that vaping might "renormalise" smoking, particularly among youth, and undermine

[1] A note on terminology: Vaping refers to e-cigarette use. The terminology for describing e-cigarette use has evolved since I started my PhD: initially the term e-cigarette use was used in research, although the term vaping is now preferred among researchers and the public. Because this thesis incorporates publications from throughout my PhD, the terms vaping and e-cigarette use are used interchangeably.

declines in smoking prevalence [35, 48-56]. However, it is also possible that vaping could further denormalise and accelerate declines in smoking. Research is therefore needed to understand social norms towards smoking and vaping, particularly their associations with smoking and vaping behaviours and policies. Such research is crucial to inform policies regulating both tobacco cigarettes and e-cigarettes, and ultimately contribute towards the improvement of public health.

1.4. Literature review

1.4.1. Social norms: their definition and measurement

Norms are one of the strongest themes in social science. Human behaviour is often described and explained using norms [63-66]. However, there is considerable variation in the way that norms are conceptualised and defined [63-65]. This research concentrates on *social norms*, which can be separated into two distinct domains: descriptive and injunctive [63].[2] Descriptive norms refer to perceptions of the behaviour of a social group [63]; injunctive norms refer to perceptions of what a social group believe people should or should not do, or how approved of behaviour is perceived to be among a social group [63]. Descriptive norms can therefore be measured by assessing perceptions of how common a behaviour is, while injunctive norms can be measured by assessing perceptions of how approved or disapproved of a behaviour is, among different social groups [63]. Given this, renormalisation describes the process of a person's perceptions of a behaviour going from less common and/or approved of to more common and/or approved of, while denormalisation is the reverse.

1.4.2. The influence of social norms on behaviour

Social norms have an important impact on behaviour [63, 64, 66, 69, 73-76]. From an evolutionary perspective, humans are social animals who have been equipped

[2] Descriptive norms as they are defined in this thesis have sometimes been referred to as group norms [67] and behavioural norms [68]. Injunctive norms have sometimes been referred to as to as subjective norms [69] and prescriptive or proscriptive norms [70-72].

with psychological mechanisms that compel them to engage in behaviours that are more common or approved of [64]. Engaging in behaviours that are more common and/or approved of is likely to facilitate cooperation and thus help create and maintain social structures [64]. Conforming to social norms is thus commonly valued and pursued [64]. Further, inhabiting social environments where a behaviour is more common or approved of may facilitate the initiation or maintenance of a behaviour by providing cues or opportunities for that behaviour to take place [63, 77]. Importantly, studies have found that perceptions of others' behaviours and attitudes can be stronger predictors of health-related behaviour than the actual behaviours and attitudes of others [78-80].

Social norms are a central component of several behavioural theories [81]. Bandura's Social Cognitive Theory states that humans learn through social influence [73, 76]. Specifically, that individuals copy the behaviour of those around them (i.e., descriptive norms) and copy behaviour that they see as being rewarded or approved of (i.e., injunctive norms) [73, 76]. Social Cognitive Theory predominantly focuses on the social influences of those closest to you, such as parents or close friends, although it can extend to wider social groups [73, 76, 82].

The Theory of Planned Behaviour focuses on injunctive norms in addition to one's own attitudes and perceived behavioural control regarding a behaviour [66]. The Theory of Planned Behaviour posits that these three components determine intention to perform that behaviour, which in turn predicts the behaviour itself [66]. Meta-analyses have found that all three components of the Theory of Planned Behaviour predict behaviour and intentions [83-89] and that descriptive norms, although not included in Ajzen's model [66], are important to consider as an additional distinct component [89, 90]. Interestingly, one of these meta-analyses found that injunctive norms are stronger correlates of intentions than descriptive norms, yet descriptive norms are stronger correlates of actual behaviour [90]. Similar to Social Cognitive Theory [73, 76], the Theory of Planned Behaviour usually also focuses on the social influences of people important to the individual [83, 86-90].

The more recent and multi-faceted PRIME (Plans, Responses, Impulses, Motives, Evaluations) Theory of addiction proposes that the environment, including social norms, are conducive to the development and maintenance of addictive behaviours [58]. Importantly, according to PRIME Theory, the social norms from closer social groups are more important than the social norms of society: "if an activity is seen as normal within the social group with which the person identifies… that immediate social group will tend to be more influential than the wider society" (pg 235 in [58]).

1.4.3. Social norms towards tobacco smoking

In the tobacco smoking literature, descriptive norms have been assessed by measuring an individual's perceptions of smoking among their family, close friends, people their age (peers), society, or other groups [15, 81, 91-93]. Injunctive norms have been assessed by measuring an individual's perceived approval of smoking among their family, close friends, peers, society, or other groups [15, 81, 91-93]. Previous research and theories have argued that it is important to distinguish between the descriptive and injunctive norms of different social groups when predicting smoking behaviour [58, 90, 94].

Associations between some social norms and smoking behaviours are well documented. When considering the norms relating to an individual's close social circle, adult smokers with fewer close friends who smoke are more likely to intend to quit smoking and succeed in subsequent attempts [77]. A social network analysis of smokers and non-smokers followed over thirty years found that smoking cessation by an individual's spouse, sibling, friend, or colleague decreased the risk of that individual smoking, suggesting that smoking behaviour spreads through groups of interconnected people [95].

While fundamentally different from adult smokers, some social norms have also been associated with smoking among youth. Parent and sibling smoking have been found to be strong and reliable predictors of smoking initiation in a meta-analysis [96]. Close friend smoking has also been found to predict youth smoking initiation in another review (an effect termed "socialisation") [97, 98]. However, it has also been found that youth select friends who have similar behaviours to them (an effect termed "selection") [97, 98]. In a broader and more recent systematic review exploring the predictors of youth smoking initiation, smoking among family members and close friends, and perceived approval of smoking by parents, were all found to be positively associated with smoking initiation in several studies [99]. Further, in the one meta-analysis assessing associations between the three components of the Theory of Planned Behaviour (injunctive norms, attitudes, perceived behavioural control) and youth smoking behaviour, the injunctive norms of close others had the strongest association with intention to smoke, which was subsequently associated with behaviour [87]. However, this meta-analysis did not consider descriptive norms [87].

There is less evidence available on the association between the social norms of wider social groups and smoking behaviour. Among adults, perceiving that society disapproves of smoking has been associated with intention to quit smoking in cross-sectional analyses [94] but not quit attempts or quit success in longitudinal analyses [100]. Among youth, the systematic review exploring the predictors of youth smoking initiation also found that perceived peer smoking prevalence and peer approval of smoking were positively associated with smoking initiation in some studies [99]. However, overall there were few studies assessing these norms [99]. Perceiving that more adults smoke has also been found to predict youth smoking initiation in some studies [101, 102], but not others [103]. Perceived community disapproval of smoking was also not found to be associated with smoking initiation in another study [104]. Therefore, while there is evidence that the descriptive and injunctive norms of closer social groups, such as family and close friends, predict smoking behaviour, the influence of social norms among wider social groups is less clear.

Among youth, there have also been some smoking prevention programmes aiming to change social norms towards smoking as a means of reducing smoking prevalence [105-108]. The A Stop Smoking in Schools Trial (ASSIST) was a peer-led smoking prevention programme that encouraged the dissemination of anti-smoking norms across 30 British schools [105, 106]. This programme was found to reduce the odds of being a smoker (reporting smoking in the past week) two years later [106]. Other smoking prevention programmes focussing on resisting peer pressure to smoke and social support for not smoking have also been found to reduce smoking in schools one year later [107, 108]. Changing social norms towards smoking may therefore help to reduce smoking prevalence among youth.

1.4.4. Tobacco control and the denormalisation of smoking

As stated in the rationale for this research (Section 1.3), the implementation of comprehensive tobacco control policies alongside decreasing smoking prevalence in many countries has led to the assumption that smoking has become denormalised. Several population-level tobacco control efforts focus on denormalising smoking [57, 109]. Social norms are often also placed on the pathway between tobacco control policies and behavioural outcomes, such as quit attempts, quit success, switching to less harmful forms of using nicotine, and ultimately a reduction in smoking prevalence [59-62]. The PRIME Theory of addiction also states that population-level policies that denormalise smoking in the social environments that smokers inhabit should encourage them to quit [58]. It is possible that these policies also denormalise smoking among youth and discourage youth from initiating smoking.

Some policies may influence social norms directly. For example, smoke-free legislation restricts smoking in most indoor and some outdoor public places, thus reducing the visibility of smoking and possibly perceptions of how common and approved of smoking is [57]. Indeed, perceptions of the number of adult and peer smokers and societal approval of smoking have been found to decrease after the implementation of smoke-free policies in some communities [110-112]. Exposure to indoor smoking restrictions and noticing anti-tobacco information have also been associated with perceiving greater unacceptability of smoking in some countries [100, 113]. Further, perceived peer smoking prevalence has been found to decrease after the removal of point-of-sale tobacco displays [114]. Some anti-smoking mass media campaigns highlight the negative health and social consequences of smoking, and have been found to reduce the perceived prevalence and approval of smoking [115, 116]. Other tobacco control policies such as advertising and promotion bans, graphic health warnings, and plain packaging may also convey social denormalisation of smoking and have been found to reduce how common and approved of smoking is perceived to be [117-119].

These efforts may have a cumulative effect, such that smoking is more denormalised in communities or countries with stronger tobacco control policies [57]. Indeed, youth and adults in the US have been found to perceive that smoking is less common and approved of among adults in their town when residing in towns with stronger tobacco control policies [120].

Policies may also influence social norms by reducing smoking prevalence and increasing quit attempts [121-128]. Stronger tobacco control policies have been associated with greater declines in smoking prevalence across countries [24, 25]. Among youth and adults in countries such as Great Britain and the US, smoking prevalence has also decreased alongside increasingly comprehensive tobacco control policies [18, 26, 129, 130]. For example, in Great Britain adult smoking prevalence has more than halved in the last 40 years, down from 46% in 1974 to 17% in 2018 [26]. Smoking is thus less common and visible, potentially conveying more anti-smoking descriptive norms, particularly if smoking decreases within one's close social circle.

Among adult smokers, smoking denormalisation was found to be lower in the UK than Canada, Australia, and the US in 2002-2003 [113]. At this time, the UK had the highest smoking prevalence of these four countries [131]. Further, among the general populations of 27 European countries, favourable attitudes towards smoking restrictions were found to be greater in countries with stronger tobacco control policies and lower smoking prevalence rates [132]. While one's own attitudes do not constitute social norms according to the definition in Section 1.4.1 above, smoking attitudes and smoking norms have been found to be correlated [87, 93, 133].

Despite increasingly comprehensive tobacco control policies and decreasing smoking prevalence in many countries, prior to my PhD there had been no research formally assessing whether smoking has become denormalised over time. There had also been no research exploring whether both descriptive and injunctive norms towards smoking differ across countries with different policies and prevalence rates. One recent study among British youth, published in 2019, found that the proportion of youth who perceive smoking as "OK" has decreased between 1998 and 2015 [134]. However, another study among adult smokers found that reporting societal disapproval of smoking as a reason for quitting was found to increase between 2002 and 2015 in the US, decrease in Canada, and show non-linear trends in the UK and Australia [135]. However, this study [135] measured reasons for quitting smoking based on social norms rather than social norms themselves. These studies also did not consider perceptions of how common or approved of smoking is among different social groups [134, 135]. If smoking norms are indeed on the pathway between policies and reductions in smoking prevalence as theorised [58-62], smoking should be perceived as both less common and approved of where tobacco policies are stronger and smoking is less prevalent.

1.4.5. Social norms towards vaping

While there is substantial literature on social norms towards smoking, e-cigarettes are a comparatively new product and less is known about the social norms surrounding them. Some social norms towards vaping have been associated with vaping behaviours in cross-sectional studies. Specifically, youth with close friends who vape and who perceive vaping to be approved of among society have been found to be more susceptible to (i.e., open to trying in the next year), and more likely to try, vaping [136, 137]. In my previous cross-sectional work, I also found that youth and adults who currently vape perceived vaping to be more common and approved of compared to individuals who had never tried vaping [15]. A peer-reviewed publication I also contributed to during my PhD found that, among adult smokers and ex-smokers, reporting seeing vaping in public, having close friends or a partner who vapes, and perceiving that society or people important to you approve of vaping, were all more common among vapers and ex-vapers than those who had never vaped [138]. Additionally, some youth and adults report trying vaping because their friends vape or have encouraged them to vape [139-141].

To my knowledge, prior to my PhD there had been no longitudinal studies exploring the associations between vaping norms and vaping behaviour. Cross-sectional studies are limited in that they cannot determine the direction of associations between norms and behaviour. As mentioned above in Section 1.4.3, associations between friend smoking and youth smoking behaviour can emerge because of both socialisation (friends' social norms influence youth smoking) and selection (youth select friends who have similar behaviours and attitudes as them) effects [97, 98]. Socialisation and selection effects are both likely generalisable to vaping norms, and perhaps also to other social groups. Longitudinal studies are therefore required to understand whether norms can precede and predict vaping behaviour.

1.4.6. The potential of vaping to change social norms towards smoking

As stated in the rationale for this research (Section 1.3), the potential of vaping to change social norms towards smoking has been discussed in several government reports and academic publications [35, 48, 50-56]. This literature predominantly focuses on the renormalisation of smoking and increases in youth smoking, with considerably less attention given to the prospect of denormalisation. While some mechanisms for renormalisation have been proposed [15, 50, 55, 56] and several studies have assessed trends in smoking prevalence since e-cigarettes were introduced to the market [27, 134, 142, 143], there has been little research into the associations between vaping norms and smoking behaviours, or the converse, smoking norms and vaping behaviours.

1.4.6.1. Vaping and smoking renormalisation

Theoretical mechanisms through which vaping might renormalise smoking often focus on the similarities between both behaviours [15, 50, 55, 56]. The act of vaping somewhat imitates that of smoking, with the user exhaling an inhaled vapour from a hand-held object. Observation of others engaging in or approving of a behaviour somewhat similar to smoking, or one's own engagement with that behaviour, could therefore lead smoking to be perceived as more common or approved of [15, 50, 55, 56]. This could subsequently promote smoking initiation or impede quitting [15, 50, 55, 56]. E-cigarette advertising, promotion, and sponsorship have also been implicated in smoking renormalisation, for similar reasons [15, 50, 55, 56].

Choi and colleagues explored these mechanisms using a cross-sectional sample of just under 70,000 youth in Florida [56]. Youth who reported living with a vaper, having vaped themselves, and being exposed to e-cigarette advertising were more likely to perceive adult smoking as acceptable and also be susceptible to smoking [56]. This suggests that exposure to e-cigarettes may be associated with perceiving smoking as more acceptable or approved of among youth and may also increase smoking if susceptibility translates to use, as has been found in previous studies [144, 145]. However, this cross-sectional study cannot infer the direction of associations and did not consider descriptive norms towards smoking.

Vaping has also been theorised to renormalise smoking through attracting non-smoking individuals, particularly youth, into nicotine use and subsequent smoking [50, 52, 55]. Most e-cigarettes often, although not always, contain nicotine, the addictive component of smoking [27]. Vaping may be a more attractive product than tobacco cigarettes because of the novelty, variety of flavours available, and reduced harm [50, 52, 55]. Non-smoking youth who initiate vaping may then be more likely to subsequently initiate smoking because of the addictiveness of nicotine and because of the behavioural similarities of vaping and smoking [50, 55, 56]. If vaping leads to more smokers, either at the population level or within one's social circle, perceptions of how common and approved of smoking is may also increase.

Several longitudinal studies have found that never smoking youth who try vaping are more likely to subsequently initiate smoking [146-156]. A meta-analysis has confirmed the strength and consistency of these associations [157]. However, Kozlowski and Warner noted that these studies did not fully account for risk factors for both vaping and smoking [158]. As such, it may be that youth who try vaping are also predisposed to trying smoking because of shared risk factors for use of both products, rather than vaping leading to smoking [158]. It is also possible that there is a reciprocal association between vaping and smoking, such that youth who try one product are more likely to use the other, regardless of which is used first. Indeed, it has been found not only that vaping is associated with smoking initiation, but also that smoking is associated with vaping initiation, among US youth [154]. Further, current smoking has been associated with vaping initiation one and a half years later among youth in Argentina [159]. Associations between smoking and subsequent vaping initiation, even among youth, are unsurprising given that vaping is often used by smokers to help them quit [27, 31, 45, 46].

Despite these theories, prior to starting my PhD no longitudinal studies had assessed associations between vaping norms and smoking initiation, or smoking norms and vaping initiation. Moreover, there had been no longitudinal studies among British youth that had explored associations between both vaping and smoking initiation and smoking and vaping initiation; associations in both directions would be expected if there is a reciprocal relationship between vaping and smoking.

1.4.6.2. Vaping and smoking denormalisation

Despite concerns surrounding the potential of vaping to renormalise smoking, the above theories often do not consider important differences between these products. E-cigarettes are not homogeneous and while some, such as cigalikes, closely resemble conventional cigarettes, others bear little obvious similarity [160]. For example, some e-cigarettes, such as Juul, are more discrete and appear more like flash drives than cigarettes [161, 162]. Further, as previously stated, e-cigarettes are less harmful than tobacco cigarettes and are often used as aids to smoking cessation or reduction [20, 27, 31, 37, 39-46]. Both quantitative and qualitative studies have found that some youth and adults accurately recognise these differences [30, 163, 164]. Adult smokers also often report starting vaping to reduce the harms from smoking [27, 38]. Therefore, rather than renormalising smoking, the availability of a reduced harm nicotine product such as e-cigarettes could reduce how socially acceptable smoking is perceived to be.

Also contrary to vaping renormalising smoking, the use of e-cigarettes as an aid to quitting smoking could denormalise smoking by reducing smoking within one's social network or at the population level. There is evidence that vaping helps some smokers quit smoking [27, 31, 45-47]. Smoking prevalence has also continued to decline among both youth and adults since e-cigarettes were introduced to the market [27, 134, 143, 165]. Among US youth, declines in smoking prevalence have also accelerated since vaping has become popular [142]. Declines in smoking prevalence in Great Britain until 2016 appear to be attributable both to a reduction in initiation and an increase in quitting [165]. Moreover, the proportion of British youth who agree that smoking is OK was found to decline between 1998 and 2015, and to accelerate after vaping became popular [134]. These trends are inconsistent with the notion that vaping is renormalising and increasing smoking, although they did not consider the associations between norms and behaviour and may not generalise to more recent years.

1.4.6.3. Associations between vaping norms and smoking, and smoking norms and vaping

Little is known about the associations between vaping norms and smoking behaviour, or the converse: smoking norms and vaping behaviour. If vaping has the potential to renormalise or denormalise smoking, associations between norms and behaviour across products are to be expected.

In a paper that I contributed to during my PhD, among adults, more ex-smokers than smokers reported that their close friends vape [138]. However, there was little evidence of associations between smoking status and seeing vaping in public, partner vaping, or perceived approval of vaping among society or people important to you [138]. In my previous research among British adults, I also found that adults who vape daily generally perceived smoking to be more common and approved, compared to individuals who had never tried vaping [15]. Vaping was also perceived as less common but more publicly approved of among adult daily smokers than ex-smokers and never smokers [15]. However, all of these studies were cross-sectional and cannot determine the direction of associations.

Among youth, those with close friends who smoke have been found to be more likely to try, or be susceptible to, vaping than those without close friends who smoke, in cross-sectional studies [136, 159, 166]. By contrast, one of these studies found little evidence of an association between close friend vaping or perceived societal approval of vaping and smoking susceptibility [136]. In my previous research on social norms, I found that British youth who currently vape perceived smoking to be more common and approved of [15]. However, I found little evidence of associations between smoking status and vaping norms among youth [15]. Again, these studies were limited to cross-sectional data.

Taken together, research to date suggests that there may be some evidence of associations between norms and behaviour across products, although the direction of associations is unclear. Longitudinal research and research across countries with different tobacco control and vaping policies is required to extend these findings.

1.4.7. Harm perceptions of vaping relative to smoking

Social Cognitive Theory posits that, in addition to individuals learning from social cues, individuals also engage in behaviours that they believe will minimise future risks [81, 167]. These risks can be physical, such as disease symptoms, or social, such as disapproval or rejection from friends or other social groups [81, 167]. Similarly, perceptions of risk surrounding a behaviour have also been theorised to predict that same behaviour indirectly via other beliefs, in the Theory of Planned Behaviour [66, 81]. Other theories, such as the Health Belief Model, also emphasise the importance of the perceived risks and benefits of engaging in a behaviour for predicting that same behaviour [168]. A meta-analysis has found that perceived risks and benefits have a strong and reliable effect on behaviour [169]. Perceiving vaping to be less harmful than smoking could therefore encourage smokers to switch from smoking to vaping or encourage individuals who would otherwise have smoked to vape instead. Indeed, accurately perceiving vaping as less harmful than smoking has been positively associated with trying vaping and being a current vaper among both youth and adults [163, 166, 170-174].

The Health Belief Model also proposes that the perceived risks of engaging in health-related behaviours can be shaped by social factors [81, 168]. Social norms towards vaping may therefore predict risk or harm perceptions of vaping relative to smoking, and thus vaping or smoking behaviour. Indeed, youth with family members who vape, smoke, or use another tobacco product have been found to be more likely to perceive vaping as less than or equally harmful than smoking, compared to more harmful [171]. However, no studies have explored the associations between smoking and vaping norms separately and harm perceptions of vaping, or norms from social groups other than family.

1.4.8. Summary of the literature and gaps identified

1.4.8.1. Summary of the literature

To summarise, social norms towards smoking and vaping can be measured by assessing perceptions of how common (descriptive norms) and approved of (injunctive norms) these behaviours are among different social groups. Some smoking norms have been found to predict smoking behaviour. Social norms are also theorised to be on the pathway between tobacco control policies and reductions in smoking prevalence. E-cigarettes are a newer product than tobacco cigarettes and less is known about the social norms surrounding them. There are concerns that vaping could renormalise and increase smoking, although it is alternatively possible that vaping could denormalise and further decrease smoking. Concerns surrounding the potential of vaping to renormalise smoking predominantly focus on youth and implications for youth smoking initiation.

1.4.8.2. Gaps in the literature and how they are addressed in this thesis

Social norms can be measured across different social groups. Associations between the social norms of those within one's close social circle (e.g., close friends and family) and youth smoking behaviours are well-documented. However, there is less evidence regarding the influence of societal-level smoking norms on youth smoking behaviours. There has also been no systematic attempt to synthesise and compare these associations. In **Chapter 2** I present and discuss the first systematic review and meta-analysis of associations between the descriptive and injunctive smoking norms of different social groups and youth smoking initiation.[3]

Studies have found that vaping predicts smoking initiation among youth, who are the focus of concerns surrounding vaping and smoking renormalisation. Two studies have also found that smoking predicts vaping initiation among youth in the US and Argentina. However, prior to starting my PhD, no studies had yet aimed to explore whether there is a reciprocal relationship between vaping and smoking among British youth. In **Chapter 4** I present and discuss the first study among British youth to explore the longitudinal associations between both vaping and smoking initiation and also smoking and vaping initiation [1].

Little is known about the social norms surrounding vaping. Few studies have explored whether vaping norms predict vaping behaviours. Few studies have also explored whether there are associations between smoking norms and vaping behaviours, and vaping norms and smoking behaviours, which should be expected if vaping has the potential to change norms towards smoking. In **Chapter 4** I also explore these associations using a longitudinal survey of British youth [1]. In **Chapter 6** I extend my findings from Chapter 4 using cross-sectional data from across three countries [3].

Vaping is less harmful than smoking. Theories have proposed that social norms may play a role in shaping harm perceptions and subsequent behaviour. In **Chapter 5** I present and discuss the first study assessing the associations between smoking and vaping norms and the relative harm perceptions of vaping among a nationally representative sample of British youth [2]. In Chapter 5 I also explore the associations between smoking and vaping norms and harm perceptions of nicotine, another novel contribution to the literature [2]

It is often assumed that smoking has become denormalised alongside the implementation of comprehensive tobacco control policies and decreasing

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[3] In **Chapter 3** I describe the survey research methodology used Chapters 4-8 [1-5].

smoking prevalence. However, prior to my PhD there had been no formal assessment of this, nor of how vaping policies and vaping prevalence rates are associated with vaping norms. In **Chapters 6-8** I explore these issues [3-5]. In **Chapter 6** I present and discuss the first study among youth to assess differences in smoking and vaping norms across countries with different tobacco control and vaping policies and different smoking and vaping prevalence rates (England, Canada, US) [3]. In **Chapter 7** I extend the findings from Chapter 6 to adult smokers across seven European countries [4]. In **Chapter 8** I explore trends in smoking norms over time and differences across countries (UK, Canada, US, Australia) among adult daily smokers [5].

1.5. Aims and objectives of this research

The overall aim of this thesis was to explore the associations between smoking and vaping norms and smoking and vaping behaviours and policies.

To achieve this overall aim, the following specific aims were developed:

To assess, among youth, the associations between:

Aim 1. Smoking norms and smoking behaviours

Aim 2. Vaping norms and vaping behaviours

Aim 3. Vaping norms and smoking behaviours, and smoking norms and vaping behaviours

Aim 4. Vaping initiation and smoking initiation

Aim 5. Smoking and vaping norms and harm perceptions of vaping and nicotine relative to smoking

To assess, among youth, and adult smokers, whether:

Aim 6. Smoking norms correspond with tobacco control policies and smoking prevalence rates

Aim 7. Vaping norms correspond with vaping policies and vaping prevalence rates

These aims are addressed through separate studies presented in Chapter 2 (systematic review and meta-analysis) and Chapters 4-8 (peer-reviewed publications [1-5]). These Chapters have separate objectives, shown in Figure 1.1.

Figure 1.1. Chapter objectives and corresponding thesis aims

Chapters	Chapter objectives (thesis aims addressed)
Chapter 2. Systematic Review and Meta-Analysis of Smoking Norms and Smoking Initiation Among Youth	(i) Assess whether smoking norms are predictive of youth smoking initiation and escalation and (ii) assess and compare the effects of different smoking norms on youth smoking initiation **(Aim 1)**
Chapter 4. Smoking and Vaping Initiation and Norms and Among British Youth	Among British youth, assess the longitudinal associations between: (i) vaping and smoking initiation, (ii) smoking and vaping initiation, (iii) smoking and vaping norms and smoking initiation, and (iv) smoking and vaping norms and vaping initiation **(Aims 1-4)**
Chapter 5. Smoking and Vaping Norms and Harm Perceptions of Vaping and Nicotine Among British Youth	Among British youth, assess (i) the prevalence of harm perceptions of (a) vaping and (b) nicotine, relative to smoking, and (ii) the correlates of accurate harm perceptions of (a) vaping and (b) nicotine, relative to smoking **(Aim 5)**
Chapter 6. Smoking and Vaping Norms Among Youth Across England, Canada, US	Among youth in England, Canada, and the US, assess the associations between smoking and vaping norms and (i) country, (ii) smoking status, and (iii) vaping status **(Aims 1-3 and 6-7)**
Chapter 7. Smoking and Vaping Norms Among Adult Smokers Across Europe	Among adult smokers in seven European countries, assess whether (i) smoking norms correspond with smoking prevalence, (ii) vaping norms correspond with vaping prevalence, and (iii) smoking norms correspond with tobacco control policy strength **(Aims 6-7)**
Chapter 8. Trends in Smoking Norms Over Time Among Daily Smokers Across UK, Canada, US, Australia	Among adult daily smokers in the UK, Canada, the US, and Australia, assess (i) trends in smoking norms and opinions between 2002 and 2015 and (ii) differences in smoking norms and opinions across countries **(Aim 6)**

Chapter 3 details the survey research methodology used in Chapters 4-8 and is not included in this figure.

CHAPTER 2

Systematic Review and Meta-Analysis of Smoking Norms and Smoking Initiation Among Youth

2.1. Preface

Chapter 2 describes the first systematic review and meta-analysis of the longitudinal associations between the smoking norms of different social groups and smoking initiation among youth.

The objectives of this Chapter were to (i) assess whether smoking norms predict youth smoking initiation and escalation, via a systematic review, and (ii) assess and compare the effects of different smoking norms on youth smoking initiation, via a meta-analysis and meta-regression.

This objective relates to *Aim 1* of my thesis: To assess, among youth, the associations between smoking norms and smoking behaviours.

This Chapter being prepared for publication as:

> *East, K., McNeill, A., Thrasher, J. F. & Hitchman, S. C. (2018). Social norms as a predictor of smoking initiation among youth: a systematic review, meta-analysis, and meta-regression.*

2.1.1. Declaration of roles

The content of this Chapter was developed in collaboration Dr Sara C Hitchman and Professor Ann McNeill (King's College London) and Professor James F Thrasher (The University of South Carolina). JFT had previously conducted an unpublished review of social norms towards smoking, which was used to inform the work in Chapter 2. I formulated the research questions, screened the articles, extracted the data, and analysed the data with input from SCH and AM. SCH and AM performed screening checks, and AM performed data extraction checks. SCH and AM reviewed and provided input on the write-up of Chapter 2. Erikas Simonavicius (King's College London) also screened articles for the systematic review.

2.1.2. Funding statement

The work in this Chapter was funded by a PhD studentship from the UK Centre for Tobacco and Alcohol Studies (UKCTAS). UKCTAS had no role in formulating the research questions, screening, data extraction, data analysis, or write-up.

2.2. Introduction

Smoking is largely taken up before the age of 18 [18, 175] and an estimated 207,000 children age 11-15 initiate smoking in the UK each year [176]. Nicotine in cigarettes is highly addictive [16, 20, 21]. Smoking initiation is therefore a hazardous behaviour which puts youth at risk for developing an addiction to smoking, and smoking-related diseases [16]. Identifying modifiable predictors of youth smoking initiation is crucial.

As stated in Chapter 1 of this thesis, social norms have been found to predict youth smoking behaviour, are a central component of behavioural theories of smoking, and are targeted by some interventions and policies to reduce smoking (see Sections 1.4.1 to 1.4.4 above). Yet, despite the popularity of social norms in tobacco research and policy, the effects of descriptive and injunctive norms across different social groups on youth smoking initiation have not yet been systematically reviewed, quantified, or compared.

Youth who report having more family members and close friends who smoke (descriptive norms) and who perceive approval of smoking by family members and close others (injunctive norms) have been found to be more likely to initiate smoking [87, 96, 97, 99]. However, there have also been several studies that had failed to find associations between these norms and youth smoking behaviours [99]. Moreover, very few studies have explored the associations between societal-level social norms and youth smoking behaviours [99]. Previous systematic attempts to synthesise the research on associations between social norms and youth smoking initiation have only considered family smoking [96] or were a broader narrative review of predictors of youth smoking with no attempt to pool data statistically via a meta-analysis [99].

The objectives of Chapter 2 are therefore to (i) assess whether smoking norms predict youth smoking initiation and escalation via a systematic review, and (ii) assess and compare the effects of different smoking norms on youth smoking initiation via a meta-analysis and meta-regression. Escalation of smoking is explored in the systematic review in addition to initiation of smoking because it may provide evidence of progression to more established smoking and may have different associations with smoking norms. However, escalation of smoking was not included in the meta-analysis because of the anticipated heterogeneity of escalation outcomes across articles.

2.3. Methods

2.3.1. Protocol

The protocol for this systematic review, meta-analysis, and meta-regression was registered on PROSPERO (the International Prospective Register of Systematic reviews; ID: CRD42016033416) [177]. This systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The PRISMA checklist is available in Table A1 in Appendix A.

2.3.2. Search strategy

MEDLINE (Medical Literature Analysis and Retrieval System Online), EMBASE (Excerpta Medica database), PsycINFO and CINAHL (Cumulative Index to Nursing and Allied Health Literature) were searched from 1st January 1998 to 1st June 2019 in two phases: during the first year of my PhD (1st January 1998 - 1st January 2017) and during the final year of my PhD to update the search to include more recent articles (1st January 2017 - 1st June 2019). The search terms were informed by my previous work [15] and an unpublished review by JFT, and were agreed upon by the review team (KE, AM, JFT, SCH). The search terms and full search strategy are available in Appendix B.

2.3.3. Article selection

2.3.3.1. Inclusion criteria

Population: Youth age ≤24 years (United Nations definition of youth [178]) at baseline.

Exposure: Articles that assessed a self-reported descriptive norm of wider social groups (i.e., perceived peer/adult/societal smoking prevalence) or any injunctive norm towards smoking. Descriptive norms were defined as an individual's perceptions of smoking among a social group [63]. Injunctive norms were defined as an individual's perceptions of how approved of or acceptable a behaviour is perceived to be among a social group, or perceptions of what a social group believe people should or should not do [63]. Articles were excluded if they only assessed descriptive norms within one's close social circle (i.e., family, close friends) because of time constraints and the vast number of articles identified that only assessed these types of norm (N=131). There had already been reviews synthesising evidence on the associations between family [96] and close friend [97] smoking and youth smoking initiation, and this exclusion criterion would not have influenced the results for any other social norms.

Outcome: Articles that assessed smoking initiation (any smoking at follow-up from baseline never smoking) or smoking escalation (any other increase in smoking between baseline and follow-up).

Date: Obtained data in/after 1998. This date was chosen for its significance as the date of the first comprehensive smoking ban, in California (US).

Design: Observational longitudinal survey methodology and reported the longitudinal association between norms at baseline and smoking initiation or escalation at follow-up. Observational survey methodology was selected to minimise heterogeneity between studies and because my previous work suggested that most studies in this field used observational survey methodology [15]. Longitudinal studies were selected in order to establish temporality in the associations between norms and behaviour (i.e., that smoking norms predict smoking initiation and escalation, rather than vice-versa).

Language: English.

Availability of summary statistics (meta-analysis only): Articles that provided (or the article's authors could provide) adequate data to calculate the odds ratios (ORs) and 95% confidence intervals (CIs) or standard errors (SEs) for the longitudinal association(s) between norms at baseline and smoking initiation at follow-up. Unadjusted associations were prioritised because of the anticipated variation in covariates adjusted for across studies. Where unadjusted associations were unavailable (or not provided by article's authors) the results from the least adjusted model were obtained. Where necessary, up to three emails were sent to the article's authors requesting this data. Articles that reported escalation of smoking as the outcome and that met all other inclusion criteria were also eligible for inclusion if article's authors could provide raw data to calculate the unadjusted associations between norms and smoking initiation.

Multiplicity of samples (meta-analysis only): Because some samples were present in more than one article, criteria were applied to select which article to include in the meta-analysis. Criteria were applied in the following order: select (1) the peer-reviewed article, (2) the article with a primary outcome measure of smoking initiation, (3) the article with the greatest number of norms measures, (4) the article with the greatest number of injunctive norms measures, (5) the article with the longest follow-up, (6) the article with the largest number of respondents.

2.3.3.2. Screening process

Articles were imported into EndNote X9 [179] and duplicates were removed. Articles were screened by one reviewer (KE) at three stages (titles, abstracts, full text). Primary reasons for exclusion were documented at the abstract and full text level. Where information necessary for assessing eligibility was missing, article's authors were contacted up to three times. The article was excluded if authors did not provide this information. Screening checks were performed by three reviewers (AM, SH, ES) each screening 50 articles at each stage. Cohen's kappa indicated moderate agreement overall (kappa=0.58) although when only considering articles screened at the full text level 100% agreement was achieved (kappa=1.0). Disagreements were resolved through discussion.

2.3.4. Data extraction

Data extraction was completed in SPSS (Statistical Package for the Social Sciences) v22 [180] by one reviewer (KE) and independently checked by another (AM). Two data extraction sheets were generated: (1) narrative synthesis, containing information derived from the articles (Appendix C) and (2) meta-analysis, containing the unadjusted associations or associations from the least adjusted model between norms and smoking initiation (Appendix D). Data extracted were either derived from the articles or provided by the article's authors. The data extraction sheets were informed by my previous work [15] and were specified in the protocol [177].

When extracting data, norms were grouped into descriptive or injunctive and sub-grouped by social group (e.g., parents, siblings, close friends, peers, adults) to assess and compare the effects of the different norms on smoking initiation and escalation. When extracting data, several articles were found to group perceived close friend and peer approval of smoking; these were therefore coded as one injunctive norm type "perceived friend/peer approval". Several articles also grouped perceived approval of smoking from multiple close social groups (friends/family/people important to you) and these grouped norms were coded as "perceived approval from important people". Perceived pressure to smoke was included as a separate category in this review, because it was considered a type of injunctive norm (i.e., a measure of what people should or should not do) but was reported separately from injunctive norms in all articles.

For the meta-analysis, the primary summary statistic was the unadjusted (or least adjusted) OR and 95% CIs (or SEs) for the associations between each norm measure and smoking initiation. Some articles reported these summary statistics directly or reported sufficient data for them to be calculated using the Campbell Collaboration's Effect Size Calculator [181]. If the requisite summary statistics could not be obtained or calculated, the article's authors were contacted (up to three emails were sent requesting data).

2.3.5. Risk of bias assessment

Risk of bias within individual studies was assessed by one reviewer (KE) using the adapted 5-star version of the Newcastle-Ottawa Quality Assessment Scale for Cohort Studies (adapted version from Taylor et al. [182]). The adapted Newcastle-Ottawa Scale scores range from 0 to 5 stars, with a score of ≤3 stars indicating a high risk of bias [182].

The Newcastle-Ottawa Scale was used as instructed in Taylor et al. except "Ascertainment of outcome" and "Ascertainment of exposure" were switched so that "Ascertainment of outcome" was awarded one star if smoking status was bio-verified and "Ascertainment of exposure" was awarded one star if standardised/validated self-report measures of norms were used [182]. "Representativeness of the exposed cohort" was awarded one star if the sample was truly or somewhat representative of average youth in the community assessed. "Selection of the non-exposed cohort" was awarded one star if the sample of the non-exposed cohort was drawn from the same community as the exposed cohort. Finally, "Adequacy of follow-up of cohorts" was awarded one star if >70% were followed-up (threshold recommended in [182]) or there was a description of respondents lost to follow-up.

Publication bias was assessed using funnel plots [183] and Egger's test [184] (see Statistical analysis in Section 2.3.6 below).

2.3.6. Statistical analyses

The analyses were pre-specified in the protocol [177]. The meta-analysis data extraction sheet was exported to Stata v15 [185] for analysis. All associations between social norms and smoking initiation were stratified into (1) descriptive, (2) injunctive, or (3) perceived pressure to smoke, and further stratified by social group. The natural logarithm of the OR and 95% CIs for each association were calculated and then pooled: first overall, and second within each group (1)-(3), using a random-effects meta-analysis run using Stata's metan command [186]. Subgroup analyses stratifying norms by social group were performed within each group (1)-(3). Random-effects meta-analysis was used because it was anticipated there would be a high degree of heterogeneity.

Because of the anticipated heterogeneity across studies, a random-effects meta-regression was also pre-specified in the protocol [177]. This meta-regression was used to examine whether (1) study characteristics contributed to variation in the effect sizes (2) effect sizes varied according to norm type when adjusting for these study characteristics. Study characteristics determined a-priori included respondent characteristics (age, gender), follow-up length, and risk of bias [177]. After data extraction, I also identified additional respondent and study characteristics for inclusion in the meta-regression that may have contributed to variation in the effect sizes: country, year of data collection, setting, and outcome measure. Because of low numbers of associations (k=58), the following study characteristics were treated as categorical in the meta-regression: country (Asia, Europe, US), risk of bias (high, low), setting (school, other), year of data collection (1998-2000, 2001-2018), outcome (puffing on a cigarette vs. other). Where possible, the mean age of the sample was used. Where only age ranges were available the median of the age range was taken. Age of the sample, percentage of females in the sample, and follow-up length were treated as continuous in the meta-regression.

The random-effects meta-regression was run using Stata's metareg command [187]. First, a series of univariable meta-regressions were run with study characteristics and norm type sequentially entered as univariable predictors to assess their contribution to the variation in effect size. Second, a multivariable meta-regression was run with norm type and any study characteristic variables that were significantly associated with the effect size in the univariable analyses.

The multivariable analysis did not include any non-significant study characteristic variables because of the low number of associations (k=58).

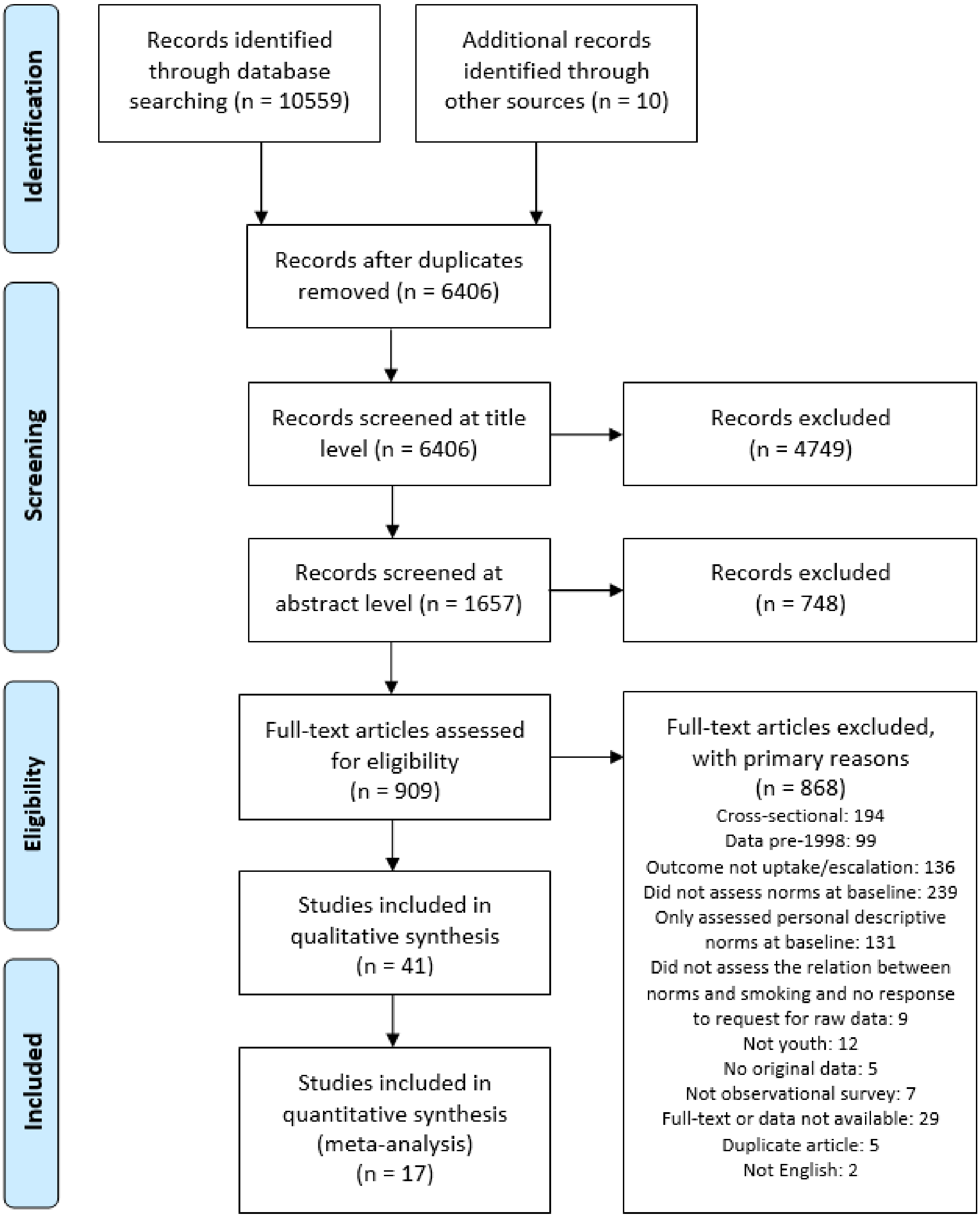
Funnel plots and Egger's test were used to assess publication bias [183, 184, 188, 189]. Egger's test was selected because it is more sensitive for detecting bias than alternative tests [184]. A non-parametric trim and fill method was then used to assess whether correcting for publication bias influenced the results [190, 191].

2.4. Results

Figure 2.1 shows the number of articles identified and included at each stage and primary reasons for exclusion. The database search generated 10,559 articles. Ten additional references were identified from hand searching, leading to a total of 10,569 articles. After removing duplicates, 6,406 remained. Following screening, 41 full texts were included in the narrative synthesis. The most common primary reasons for exclusion from the systematic review at full-text level were not assessing self-reported norms towards smoking at baseline (n=239) and use of cross-sectional data (n=194). Primary reasons for exclusion are shown because some studies had more than one reason for exclusion. The reasons for exclusion are presented in terms of what exclusion criteria became apparent first during screening.

Of the 41 articles included in the narrative synthesis, 17 had sufficient data (or authors provided sufficient data) for inclusion in the meta-analyses. Twenty four articles were excluded from the meta-analysis and Table A2 in Appendix E provides reasons for exclusion per article.

Figure 2.1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram describing article selection



2.4.1. Description of articles

Table A2 in Appendix E shows the characteristics of the 41 articles included in the systematic review and the 17 articles included in the meta-analysis. All articles except two, which were PhD theses [192, 193], were peer-reviewed publications in academic journals. The article in Chapter 4 of this thesis was included in the systematic review because it was published prior to the completion of this Chapter [1].

Design: The majority of articles (31/41) used self-report surveys administered in schools, with the remainder using self-report surveys administered in households (6/41), in universities (3/41), or online (1/41). Nineteen articles used samples from the US, 18 from Europe (five in Great Britain), and four from Asia. Follow-up duration ranged from three months to eight years, with the majority (35/41) running for three years or more.

Respondents: The number of respondents per article ranged from 193 to 11,583. The majority (25/41) had over 1,000 respondents. The youngest respondents were approximately eight years old while the oldest were 23 years old. Most articles (37/41) reported a fairly even gender split (42-60% female) and less than half (15/41) involved a majority (>50%) white sample.

Exposures (norms): Most articles assessed descriptive (33/41) or injunctive (32/41) norms. Perceived pressure to smoke was also assessed in 5 articles. There was considerable variation across articles in the measurement of social norms (see Table A2 in Appendix E). For example, some assessed best friend smoking, others assessed the smoking behaviour of several close friends, and others combined measures of best friend/friends smoking with people the same age's smoking.

Outcomes (smoking initiation and escalation): Half of articles (22/41) assessed initiation of smoking from never smoking at baseline (20 any smoking (even a puff), one established smoking (>100 cigarettes in lifetime), one at-least-monthly smoking) while half (22/41) assessed escalation in smoking using a variety of different measures (see Table A2 in Appendix E). Three of these articles assessed both initiation and escalation.

Analyses: Most articles (24/41) used a form of logistic regression as the primary analytic method. Others used linear regression, crosslagged models, survival analyses, structural equation models, general linear models, growth curve models, ANOVAs, and chi-squared. All articles except one included several covariates including other measures of smoking norms in analyses, and there was considerable variation in the covariates adjusted for across studies (see Table A2 in Appendix E).

Risk of bias: Over two thirds of articles (29/41) had a high risk of bias (a score of ≤3 stars on the Newcastle-Ottawa Scale) and scores ranged from two to five stars.

2.4.2. Narrative synthesis of the associations between norms and smoking initiation and escalation

2.4.2.1. Descriptive norms

Table 2.1 below shows the summary of the associations between descriptive social norms and smoking initiation and escalation in youth. Table A3 in Appendix F presents a detailed description of the associations between all descriptive norms and smoking outcomes.

Table 2.1. Summary of associations between descriptive norms and smoking initiation and escalation among youth from 33 articles

Norm and outcome	Number		Evidence of associations (n studies (%))		
	Articles	Respondents	Some (p<.05)	Mixed	Little (p≥.05)
Parent smoking					
Initiation	9	19,430	7 (77.7)	1 (11.1)	1 (11.1)
Escalation	9	24,728	3 (33.3)	3 (33.3)	3 (33.3)
Total	18	44,158	10 (55.5)	4 (22.2)	4 (22.2)
Sibling smoking					
Initiation	4	7,858	2 (50.0)	2 (50.0)	0 (0.0)
Escalation	4	9,640	1 (25.0)	2 (50.0)	1 (25.0)
Total	8	17,498	3 (37.5)	4 (50.0)	1 (12.5)
Family/household smoking					
Initiation	6	10,230	2 (33.3)	3 (50.0)	1 (16.7)
Escalation	3	1,131	2 (66.7)	0 (0.0)	1 (33.3)
Total	9	11,361	4 (44.4)	3 (33.3)	2 (22.2)
Close friend smoking					
Initiation	15	27,216	8 (53.3)	3 (20.0)	4 (26.7)
Escalation	12	35,435	5 (41.7)	7 (58.3)	0 (0)
Total	27	62,651	13 (48.1)	10 (37.0)	4 (14.8)
Romantic partner smoking					
Initiation	0	0	NA	NA	NA
Escalation	1	779	1 (100.0)	0 (0.0)	0 (0.0)
Total	1	779	1 (100.0)	0 (0.0)	0 (0.0)
Perceived prevalence of peer smoking					
Initiation	5	10,350	2 (40.0)	1 (20.0)	2 (40.0)
Escalation	9	34,317	4 (44.4)	3 (33.3)	2 (22.2)
Total	14	44,667	6 (42.8)	4 (28.5)	4 (28.5)
Perceived prevalence of adult smoking					
Initiation	3	5,548	2 (66.7)	0 (00.0)	1 (33.3)
Escalation	2	6,749	2 (100.0)	0 (0.0)	0 (0.0)
Total	5	12,297	4 (80.0)	0 (00.0)	1 (20.0)

NA=Not Applicable

2.4.2.1.1. Parent smoking

Initiation: Parent smoking was positively associated with smoking initiation in the majority (7/9) of articles [1, 101, 133, 194-197] (Table 2.1), most of which adjusted for a wide range of covariates including other measures of smoking norms (Table A3 in Appendix F). There was mixed evidence of associations with initiation in one article, which found that mothers' smoking increased the odds of initiating smoking in both unadjusted analyses and adjusted analyses, but fathers' smoking was significant in unadjusted analyses but not when adjusting for covariates including other measures of smoking norms [198] (Table A3 in Appendix F). There was no significant associations with initiation in one article [104], which only reported the unadjusted associations (Table A3 in Appendix F).

Escalation: Parent smoking was positively associated with smoking escalation in a third of articles (3/9) [199-201], while a third of articles (3/9) [91, 92, 202] found little evidence of associations (Table 2.1) All of these articles adjusted for a wide range of covariates including other measures of smoking norms (Table A3 in Appendix F). There was mixed evidence of associations with escalation in the remaining third of articles (3/9): two found that parent smoking was associated with escalation of smoking from some smoking stages but not others [203, 204] and one found that the association between parent smoking and smoking escalation was dependent on parent approval of smoking [205] (Table A3 in Appendix F).

2.4.2.1.2. Sibling smoking

Initiation: Sibling smoking was positively associated with smoking initiation in 2/4 articles [101, 196] (Table 2.1), both of which adjusted for covariates (Table A3 in Appendix F). There was mixed evidence of associations with initiation in the remaining 2/4 articles, both of which found that sibling smoking was associated with smoking initiation in unadjusted analyses but not when adjusting for several covariates including other measures of smoking norms [1, 197] (Table A3 in Appendix F).

Escalation: Of the four studies that assessed sibling smoking and associations with smoking escalation, one found a positive association [199] while one found little evidence of an association [91] (Table 2.1). Both of these articles adjusted for several covariates including other measures of smoking norms (Table A3 in Appendix F). The remaining 2/4 of articles found mixed evidence of associations: one found sibling smoking was associated with smoking in unadjusted analyses, but not when adjusting for covariates including other measures of smoking norms [202], and one found that sibling smoking was associated with escalation of smoking from some smoking stages but not others [204] (Table A3 in Appendix F).

2.4.2.1.3. Family/household smoking

Initiation: Of the six studies that assessed the associations between family/household smoking and smoking initiation, two found positive associations [206, 207] while one found little evidence of associations [146] (Table 2.1). All three of these articles adjusted for covariates (Table A3 in Appendix F). The remaining 3/6 articles had mixed evidence of associations with initiation (Table 2.1): two found associations in unadjusted but not adjusted analyses [102, 103], while the other found associations between having two or more (but not one) smoking family members and smoking [152] (Table A3 in Appendix F).

Escalation: Of the three studies that assessed the associations between family/household smoking and smoking escalation, two found positive associations when adjusting for several covariates including other measures of smoking norms [93, 152] while one found little evidence of associations in unadjusted analyses [208] (Table 2.1 and Table A3 in Appendix F).

2.4.2.1.4. Close friend smoking

Initiation: Close friend smoking was the most commonly assessed norm in the articles included (Table 2.1). Close friend smoking was positively associated with smoking initiation in just over half (8/15) of articles [1, 101-103, 146, 152, 196, 197], while 4/15 articles found little evidence of associations between close friend smoking and smoking initiation [194, 198, 206, 209] (Table 2.1). The majority of these articles adjusted for a wide range of covariates including other measures of smoking norms (Table A3 in Appendix F). The remaining 3/15 had mixed evidence of associations with initiation (Table 2.1): two found associations before but not after adjusting for several covariates and other measures of smoking norms [104, 207] (Table A3 in Appendix F).

Escalation: Close friend smoking was positively associated with smoking escalation in just under half (5/12) of articles [93, 193, 200, 201, 210] (Table 2.1), all of which adjusted for a wide range of covariates including other measures of smoking norms (Table A3 in Appendix F). There was mixed evidence of associations with escalation in the majority (7/12) of articles: one found associations before but not after adjusting for several covariates including other measures of smoking norms [202], two found associations between certain measures of close friend smoking but not others [92, 208], one found associations between having most but not a few friends who smoke [152], two found that associations between close friend smoking and smoking were dependent on perceived accessibility of cigarettes [211], one found positive associations in males but not females [212], and one found associations between close friend smoking and escalation from some smoking stages but not others [202] (Table A3 in Appendix F).

2.4.2.1.5. Romantic partner smoking

Escalation: Romantic partner smoking was assessed in one article [92] (Table 2.1), which found that as romantic partner smoking increased, escalation increased [92] (Table A3 in Appendix F).

2.4.2.1.6. Perceived prevalence of peer smoking

Initiation: Of the five articles that assessed the associations between perceived prevalence of peer smoking and smoking initiation, two found positive associations even after adjusting for several covariates [101, 213] while two found little evidence of associations (one of which found little evidence in both unadjusted and adjusted analyses) [103, 209] (Table 2.1 and Table A3 in Appendix F). There was mixed evidence of associations in one article [104] (Table 2.1), which found associations in unadjusted but not adjusted analyses (Table A3 in Appendix F).

Escalation: Perceived prevalence of peer smoking was positively associated with smoking escalation in just under half (4/9) of articles [193, 200, 201, 203], while 2/9 articles [91, 208] found little evidence of associations (Table 2.1). Most of these articles adjusted for a wide range of covariates including other measures of smoking norms, although one article failed to find a significant association in unadjusted analyses [208] (Table A3 in Appendix F). In the remaining third (3/9) of articles there was mixed evidence of associations (Table 2.1): one found associations in unadjusted but not adjusted analyses [202], one found positive associations overall but when not when split by gender [212], and one found associations between perceived peer smoking prevalence and escalation from some smoking stages but not others [203] (Table A3 in Appendix F).

2.4.2.1.7. Perceived prevalence of adult smoking

Initiation: Of the three studies that assessed the associations between perceived prevalence of adult smoking and smoking initiation, two found positive associations [101, 102] and one found little evidence of associations [103] (Table 2.1). All of these studies adjusted for covariates (Table A3 in Appendix F).

Escalation: Of the two studies that assessed the associations between perceived prevalence of adult smoking and smoking escalation, both found positive associations and adjusted for covariates [192, 201] (Table 2.1 and Table A3 in Appendix F).

2.4.2.2. Injunctive norms

Table 2.2 shows the summary of the associations between injunctive social norms and smoking initiation and escalation. Table A4 in Appendix F presents a detailed description of the associations between all injunctive norms and smoking outcomes.

Table 2.2. Summary of associations between injunctive norms and smoking initiation, and escalation among youth from 32 articles

Norm and outcome	Number		Evidence of associations (n studies (%))		
	Articles	Respondents	Some (p<.05)	Mixed	Little (p≥.05)
Parent approval					
Initiation	10	27,217	1 (10.0)	5 (50.0)	4 (40.0)
Escalation	7	15,270	2 (28.6)	4 (57.1)	1 (14.3)
Total	17	42,487	3 (17.6)	9 (52.9)	5 (29.4)
Sibling approval					
Initiation	0	0	NA	NA	NA
Escalation	3	8,708	1 (33.3)	2 (66.7)	0 (0.0)
Total	3	8,708	1 (33.3)	2 (66.7)	0 (0.0)
Friend/peer approval					
Initiation	7	12,607	0 (0.0)	5 (71.4)	2 (28.5)
Escalation	9	15,142	3 (33.3)	2 (22.2)	4 (44.4)
Total	16	27,749	3 (18.7)	7 (43.7)	6 (37.5)
Romantic partner approval					
Initiation	0	0	NA	NA	NA
Escalation	1	779	1 (100.0)	0 (0.0)	0 (0.0)
Total	1	779	1 (100.0)	0 (0.0)	0 (0.0)
Teacher approval					
Initiation	0	0	NA	NA	NA
Escalation	1	3,521	0 (0.0)	1 (100.0)	0 (0.0)
Total	1	3,521	0 (0.0)	1 (100.0)	0 (0.0)
Important people approval					
Initiation	4	3,339	1 (25.0)	1 (25.0)	2 (50.0)
Escalation	3	1,698	1 (33.3)	0 (0.00)	2 (66.7)
Total	7	5,037	2 (28.5)	1 (14.3)	4 (57.1)
Societal approval					
Initiation	2	2,577	0 (0.0)	1 (50.0)	1 (50.0)
Escalation	0	0	NA	NA	NA
Total	2	2,577	0 (0.0)	1 (50.0)	1 (50.0)

NA=Not Applicable

2.4.2.2.1. Parent approval of smoking

Initiation: Of the ten articles that assessed the associations between perceived parent approval of smoking and smoking initiation, one found that parent disapproval of smoking was negatively associated with smoking initiation [196] while four found little evidence of associations [103, 197, 206, 214] (Table 2.2). All of these adjusted for a range of covariates, and two adjusted for parental smoking (Table A4 in Appendix F). Two articles found little evidence of associations in unadjusted analyses [103, 214] (Table A4 in Appendix F). The remaining 5/10 articles had mixed evidence of associations: two found associations in unadjusted but not adjusted analyses [104, 207], one found that the association was dependent on parent smoking [195], one found associations among boys but not girls [194], and one found associations among non-asthmatic but not asthmatic respondents [215] (Table A4 in Appendix F).

Escalation: Of the seven articles that assessed the associations between perceived parent approval of smoking and smoking escalation, two found that parent disapproval of smoking was negatively associated with smoking escalation [199, 210] (Table 2.2), both of which adjusted for several covariates including other measures of smoking norms (Table A4 in Appendix F). One article found little evidence of associations when adjusting for several covariates [216] (Table A4 in Appendix F). The majority of articles (4/7) had mixed evidence of associations (Table 2.2): one found associations in unadjusted analyses but not analyses adjusting for several covariates including other measures of smoking norms [202], one found that the association was dependent on parent smoking [205], and two found that parent approval was associated with escalation of smoking from some smoking stages but not others [203, 204] (Table A4 in Appendix F).

2.4.2.2.2. Sibling approval of smoking

Escalation: Of the three articles that assessed perceived sibling approval of smoking, one found that approval was positively associated with smoking escalation [199] (Table 2.2). This article adjusted for several covariates including other measures of smoking norms [199] (Table A4 in Appendix F). Two articles had mixed evidence of associations (Table 2.2): one found associations with escalation in unadjusted but not adjusted analyses [202], the other found that sibling approval was associated with escalation of smoking from some smoking stages but not others [204] (Table A4 in Appendix F).

2.4.2.2.3. Friend/peer approval of smoking

Initiation: Of the seven articles that assessed the associations between perceived friend/peer approval of smoking and smoking initiation, none found evidence of associations while two found little evidence of associations [146, 194] (Table 2.2) in adjusted analyses (Table A4 in Appendix F). Most articles (5/7) had mixed evidence of associations (Table 2.2): two found associations in unadjusted but not adjusted analyses [104, 214], one found associations indirectly (via intention to smoke) but not directly [133], one found associations among older but not younger siblings [216] and one found associations for non-asthmatic but not asthmatic respondents [215] (Table A4 in Appendix F).

Escalation: Of the nine articles that assessed the associations between perceived friend/peer approval of smoking and smoking escalation, a third (3/9) found that approval was positively associated with smoking escalation [92, 203, 208], while most (4/9) found little evidence of associations [91, 199, 217, 218] (Table 2.2). Most of these nine articles adjusted for a range of covariates including other measures of smoking norms (Table A4 in Appendix F). Two articles had mixed evidence of associations (Table 2.2): one found associations in unadjusted but not adjusted analyses [202] and one found that perceived friend/peer approval was associated with escalation of smoking from some smoking stages but not others [204] (Table A4 in Appendix F).

2.4.2.2.4. Romantic partner approval of smoking

Escalation: One article assessed perceived romantic partner approval of smoking (Table 2.2) and found that as romantic partner approval of smoking increased, escalation also increased [92] (Table A4 in Appendix F).

2.4.2.2.5. Teacher approval of smoking

Escalation: One article assessed perceived teacher's approval of smoking (Table 2.2) and found that youth who perceived teachers would react badly if they smoked had lower odds of escalating their behaviour from some smoking stages but not others [203] (Table A4 in Appendix F).

2.4.2.2.6. Important people approval of smoking

Initiation: Of the four articles that assessed the associations between the perceived approval of smoking among people important to the respondent and smoking initiation, one found that approval was positively associated with smoking initiation [82] and two found little evidence of associations [152, 198] (Table 2.2). All three of these articles adjusted for covariates, and the two that did not find associations adjusted for other measures of smoking norms (Table A4 in Appendix F). One article had mixed evidence of associations [219] (Table 2.2): perceived approval was positively associated with smoking initiation in girls but not boys (Table A4 in Appendix F).

Escalation: Of the three studies that assessed the associations between the perceived approval of smoking among people important to the respondent and smoking escalation, one found that approval was positively associated with smoking escalation [220] while two found little evidence of associations [93, 152] (Table 2.2). All three of these articles adjusted for covariates, and the two that did not find associations adjusted for other measures of smoking norms (Table A4 in Appendix F).

2.4.2.2.7. Societal approval of smoking

Initiation: Of the two articles that assessed perceived societal approval of smoking, one found little evidence of associations with smoking initiation in either unadjusted or adjusted (for several covariates including social norms) analyses [1] and one found that youth who perceived less community disapproval had greater odds of initiating smoking in unadjusted but not adjusted (covariates not stated) analyses [104] (Table 2.2 and Table A4 in Appendix F).

2.4.2.3. Perceived pressure to smoke

Table 2.3 shows the summary of the associations between perceived pressure to smoke and smoking initiation and escalation. Table A4 in Appendix F presents a detailed description of the associations between all perceived pressure to smoke measures and smoking outcomes.

Table 2.3. Summary of associations between perceived pressure to smoke and smoking initiation and escalation among youth from 5 articles

Norm and outcomes	Number		Evidence of associations (n studies (%))		
	Articles	Respondents	Some (p<.05)	Mixed	Little (p≥.05)
Pressure to smoke from parents					
Initiation	1	4,055	0 (0.0)	0 (0.0)	1 (100.0)
Escalation	2	7,233	0 (0.0)	1 (50.0)	1 (50.0)
Total	3	11,288	0 (0.0)	1 (33.3)	2 (66.7)
Pressure to smoke from siblings					
Initiation	0	0	NA	NA	NA
Escalation	2	7,233	0 (0.0)	1 (50.0)	1 (50.0)
Total	2	7,233	0 (0.0)	1 (50.0)	1 (50.0)
Pressure to smoke from friends/peers					
Initiation	2	4,497	0 (0.0)	2 (100.0)	0 (0.0)
Escalation	3	8,708	1 (33.3)	1 (33.3)	1 (33.3)
Total	5	13,205	1 (20.0)	3 (60.0)	1 (20.0)

NA=Not Applicable

2.4.2.3.1. Pressure from parents

Initiation: One article assessed the associations between perceived pressure to smoke from parents and smoking initiation and found little evidence of an association [194] (Table 2.3). This article adjusted for several social norms including other measures of smoking norms (Table A5 in Appendix F).

Escalation: Of the two articles that assessed the associations between perceived pressure to smoke from parents and smoking escalation, one found little evidence of an association when adjusting for age, gender, and location [204] while the other found mixed evidence [202] (Table 2.3): perceiving more pressure to smoke was positively associated with smoking escalation in unadjusted but not adjusted (for several covariates including other measures of smoking norms) analyses [202] (Table A5 in Appendix F).

2.4.2.3.2. Pressure from siblings

Escalation: Of the two articles that assessed perceived pressure to smoke from siblings, one found little evidence of an association with smoking escalation when adjusting for age, gender, and location [204] while one found mixed associations [202] (Table 2.3): perceiving more pressure to smoke from siblings was positively associated with smoking escalation in unadjusted but not adjusted (for several covariates including other measures of smoking norms) analyses (Table A5 in Appendix F).

2.4.2.3.3. Pressure from friends/peers

Initiation: Of the two articles that assessed the associations between perceived pressure to smoke from friends/peers and smoking initiation, both found mixed evidence of associations (Table 2.3): one found that perceived pressure to smoke was positively associated with initiation in adjusted (for several covariates including other measures of smoking norms) but not unadjusted analyses [198], while one found a positive association among girls but not boys [194] (Table A5 in Appendix F).

Escalation: Of the three articles that assessed the associations between perceived pressure to smoke from friends/peers and smoking escalation, one found a positive association in both unadjusted and adjusted (for several covariates including other measures of smoking norms) analyses [202], one found little evidence of an association when adjusting for several covariates including other measures of smoking norms [199], and one found mixed evidence of associations [204] (Table 2.3): perceiving pressure to smoke was positively associated with escalation of smoking from some smoking stages but not others (Table A5 in Appendix F).

2.4.3. Meta-analysis of the associations between norms and smoking initiation

Seventeen articles were included in the meta-analysis synthesising associations between smoking norms and smoking initiation among youth. The unadjusted associations between social norms and smoking initiation from baseline never smoking were available directly from 11 articles [1, 102-104, 146, 152, 195, 196, 198, 213, 219]. Authors provided data for six articles [194, 201, 205, 209, 211, 220]. No associations included were adjusted for covariates or other variables.

The 17 articles included 18 unique samples and a total of 27,767 respondents. Follow-up duration ranged from six months [1] to 5 years [102] and the largest analysis had 4351 respondents [195] while the smallest had 298 respondents [146]. The overall pooled effect size for the association between all social norms and smoking initiation was OR=1.80 (95% CI=1.62-1.99) and there was considerable heterogeneity between studies (I^2=92.8).

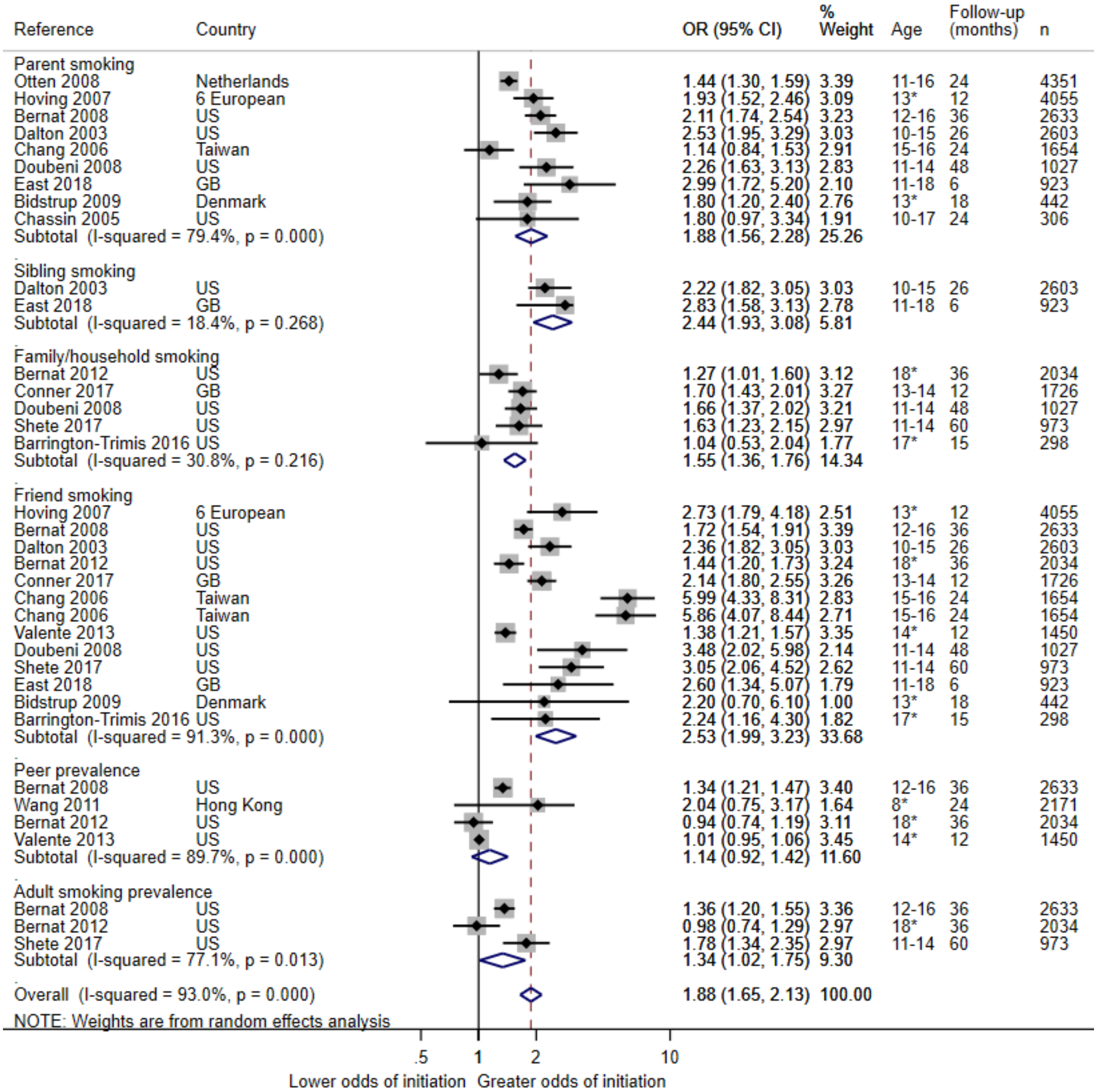
2.4.3.1. Descriptive norms

Figure 2.2 shows the results of the meta-analysis of the associations between descriptive norms and smoking initiation, split by social group. There were 36 associations across 15 articles because some articles assessed more than one descriptive norm.

Overall, descriptive norms were positively associated with smoking initiation among youth and the pooled effect size was OR=1.88 (95% CI=1.65-2.13). When split by social group, sibling smoking and close friend smoking had the largest effect sizes, while perceived smoking prevalence among adults only had a small but reliable effect (Figure 2.2). Perceived peer smoking prevalence did not have a reliable effect on youth smoking initiation (Figure 2.2).

There was considerable heterogeneity in the results, both overall (I^2=93.0) and separately for parent smoking, close friend smoking, perceived peer smoking prevalence, and perceived adult smoking prevalence (all I^2>75 indicating considerable heterogeneity [221]) (Figure 2.2).

Figure 2.2. Random effects meta-analysis of the pooled associations between descriptive norms and youth smoking initiation, grouped by social group and sorted by sample size



Country: US=United States; GB=Great Britain; 6 European=Finland, Denmark, the United Kingdom, the Netherlands, Spain, and Portugal. Age: Presented as range or mean (SD) depending on availability in source. *Mean presented (SD not available).

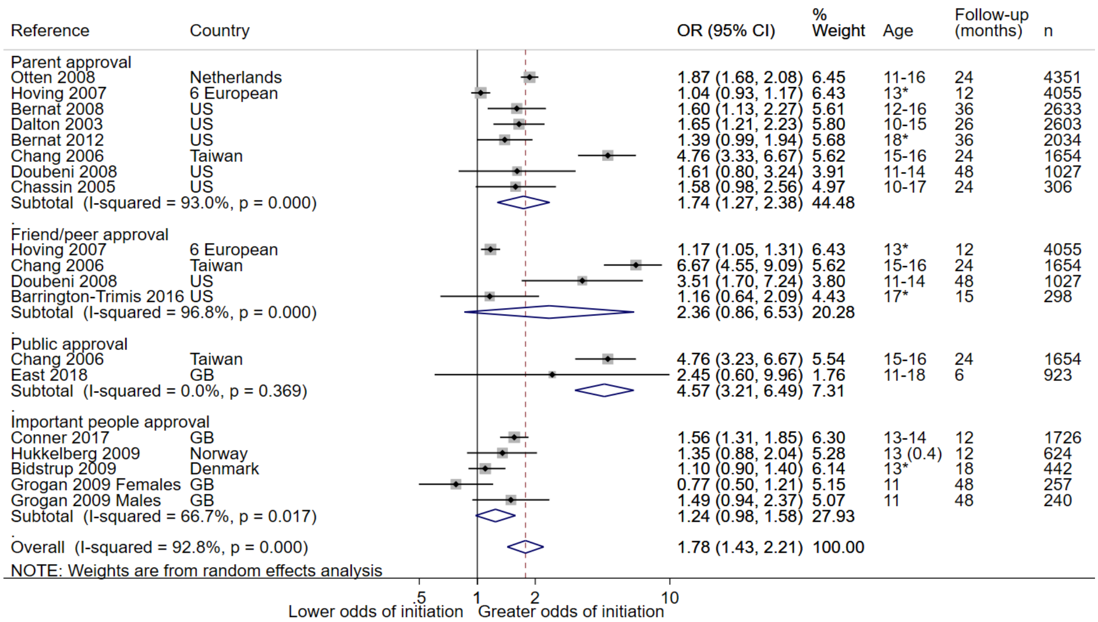
2.4.3.2. Injunctive norms

Figure 2.3 shows the results of the meta-analysis of the associations between injunctive norms and smoking initiation, split by social group. There were 19 associations across 14 articles because some articles assessed more than one injunctive norm.

Overall, injunctive norms were positively associated with smoking initiation among youth and the pooled effect size was OR=1.78 (95% CI=1.43-2.21; Figure 2.3). However, when split by social group, only perceived parent and public approval were reliably associated with smoking initiation (Figure 2.3). Perceived public approval had the largest effect size, although confidence intervals were wide indicating low precision (Figure 2.3). Perceived approval of smoking from friends/peers and people important to you did not have a reliable effect on youth smoking initiation (Figure 2.3).

Similar to the descriptive norms, there was considerable heterogeneity in the results, both overall (I^2=92.8) and for parent approval and close friend/peer approval (both I^2>75 indicating considerable heterogeneity [221]) (Figure 2.3).

Figure 2.3. Random effects meta-analysis forest plot of the pooled associations between injunctive norms and youth smoking initiation, grouped by social group and sorted by sample size



Country: US=United States; GB=Great Britain; 6 European=Finland, Denmark, the United Kingdom, the Netherlands, Spain, and Portugal. Age: Presented as range or mean (SD) depending on availability in source. *Mean presented (SD not available).

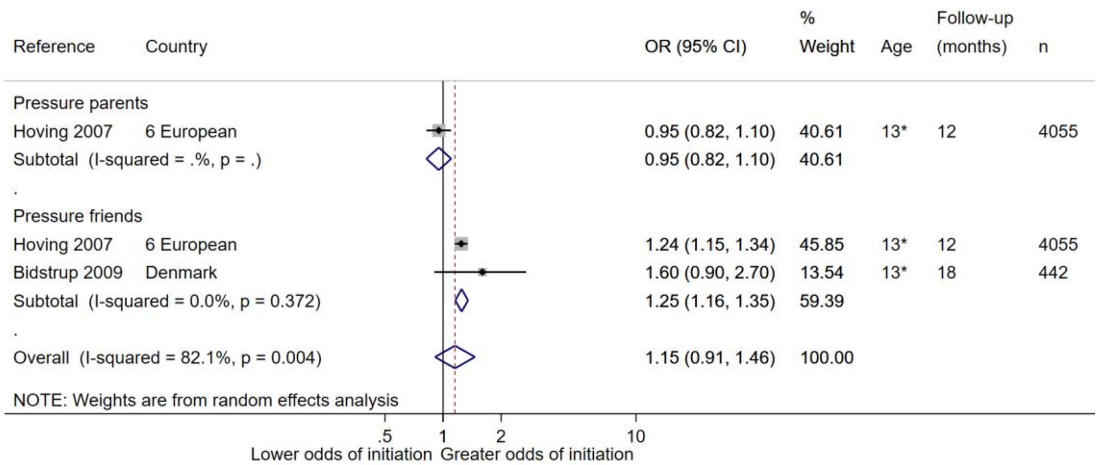
2.4.3.3. Perceived pressure to smoke

Figure 2.4 shows the results of the meta-analysis of the associations between perceived pressure to smoke and smoking initiation, split by social group. There were 3 associations across 2 articles because some articles assessed more than one measure.

Overall, perceiving pressure to smoke was not reliably associated with smoking initiation among youth when all associations were pooled (OR=1.15 [95% CI=0.91-1.46]; Figure 2.4). When split by social group, perceived pressure from friends/peers, but not perceived pressure from parents, was positively and reliably associated with smoking initiation (Figure 2.4). However, few associations were explored overall.

Similar to the descriptive and injunctive norms, there was considerable heterogeneity in the results overall (I^2=82.1) [221] (Figure 2.4).

Figure 2.4. Random effects meta-analysis forest plot of the pooled associations between perceived pressure to smoke and youth smoking initiation, grouped by social group and sorted by sample size



Country: 6 European=Finland, Denmark, the United Kingdom, the Netherlands, Spain, and Portugal. Age: Presented as range or mean (SD) depending on availability in source. *Mean presented (SD not available).

2.4.4. Meta-regression to examine whether norms and study characteristics contribute to variation in the magnitude of the effect size

Table 2.4 shows the results of the meta-regression using all 58 associations.

Univariable meta-regression: Norm type explained 28% of the variation in magnitude of the effect size, although this was not significant (Table 2.4). Country explained 90% of the variation in the magnitude of the effect size between norms and smoking initiation, and there was strong evidence that the effect size was larger among respondents from Asia than Europe or the US, but little difference between Europe and the US (Table 2.4). Risk of bias explained 12% of the variation in the magnitude of the effect size and there was strong evidence that the effect size was larger among studies with a low risk of bias (Table 2.4). Follow-up length explained 62% of the variation in the magnitude of the effect size although this was not significant. There was little evidence that any other study characteristics predicted variance in the magnitude of the effect size (Table 2.4).

Multivariable meta-regression: Norm type and the two study characteristics that were significantly ($p<.05$) associated with variation in the magnitude of the effect size were included in the multivariable meta-regression: country and risk of bias. Together, norm type, country, and risk of bias explained 55% of the variation in magnitude of the effect size (Table 2.4). Considering norm type, there was some evidence that the effect size was smaller for perceived peer smoking prevalence than parent smoking (Table 2.4). Again, there was strong evidence that effect size was larger among respondents in studies from Asia than Europe or the US (Table 2.4). There was little evidence that risk of bias predicted variance in the magnitude of the effect size (Table 2.4).

Table 2.4. Random-effects meta-regression of norm type and study characteristics on pooled effect size (k=58 associations)

Variable (univariable I^2 / Adj R^2)	k	Univariable associations OR (95% CI)	p	Multivariable associations[1] OR (95% CI)	p
Norm type (89.3/28.2)					
Parent smoking (ref)	9	1.00		1.00	
Sibling smoking	2	1.30 (0.69-2.47)	.406	1.40 (0.83-2.38)	.235
Family/household smoking	5	0.77 (0.49-1.22)	.274	0.86 (0.58-1.26)	.502
Close friend smoking	13	1.32 (0.92-1.91)	.126	1.26 (0.93-1.71)	.124
Peer smoking prevalence	4	0.62 (0.38-1.02)	.063	**0.61 (0.40-0.93)**	**.024**
Adult smoking prevalence	3	0.69 (0.41-1.19)	.189	0.75 (0.48-1.19)	.244
Parent approval	8	0.91 (0.60-1.36)	.652	0.90 (0.65-1.27)	.627
Friend/peer approval	4	1.21 (0.72-2.03)	.464	1.08 (0.69-1.67)	.636
Important people approval	5	0.64 (0.40-1.02)	.063	1.27 (0.62-2.60)	.482
Public approval	2	2.16 (0.98-4.77)	.055	0.57 (0.29-1.12)	.156
Pressure from parents	1	0.49 (0.22-1.12)	.095	0.81 (0.46-1.42)	.538
Pressure from friends/peers	2	0.72 (0.37-1.38)	.324	0.69 (0.46-1.04)	.088
Study characteristics					
Country (40.1/90.2)					
Asia (ref)	7	1.00		1.00	
Europe	22	**0.39 (0.28-0.56)**	**<.001**	**0.49 (0.34-0.71)**	**<.001**
US	29	**0.41 (0.29-0.58)**	**<.001**	**0.50 (0.35-0.72)**	**<.001**
Risk of Bias (91.4/12.4)					
Low (NOS >3) (ref)	22	1.00		1.00	
High (NOS ≤3)	36	**0.71 (0.55-0.91)**	**.007**	0.89 (0.71-1.10)	.481
Follow-up length[2] (92.0/62.0)	58	1.00 (0.99-1.01)	.913		
Age[2] (92.9/1.9)	58	0.99 (0.93-1.05)	.788		
% female[2] (92.9/1.9)	58	0.98 (0.97-1.00)	.095		
School setting (92.8/0.3)					
Yes (ref)	39	1.00			
No	19	0.80 (0.67-1.16)	.388		
Data collection year (92.8/0.8)					
1998-2000 (ref)	26	1.00			
2001-2018	32	0.86 (0.67-1.11)	.277		
Outcome (92.9/3.1)					
Any smoking (even a puff)	41	1.00			
Other	17	1.24 (0.95-1.63)	.106		

Multivariate model I^2=83.62, Adj. R^2=54.88.

[1] Multivariable analyses only include norm type and the study characteristics significant (at p<.05) in univariable analyses. [2] Continuous variables. k=number of associations. I^2=the percentage of residual heterogeneity that is attributable to between-study heterogeneity. Adjusted R^2=the percentage of between-study heterogeneity explained by the norm type/study characteristic. NOS=Newcastle-Ottawa Scale score.

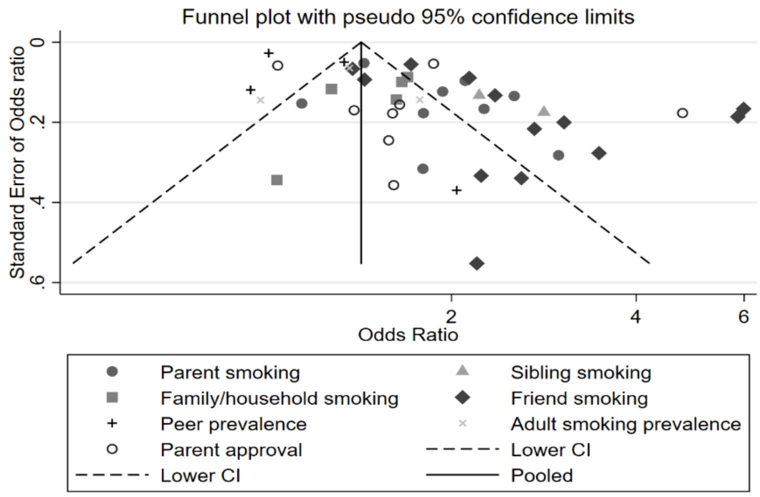
2.4.5. Publication bias

Figure 2.5 below shows the three funnel plots for (1) descriptive norms, (2) injunctive norms and (3) perceived pressure to smoke. There was asymmetry in all three funnel plots and all plots indicated few smaller-sized studies with negative effects suggesting some degree of publication bias [183] (Figure 2.5). Egger's test found strong evidence of publication bias for descriptive norms ($p<.001$) but not injunctive norms ($p=.167$) or perceived pressure to smoke ($p=.909$).

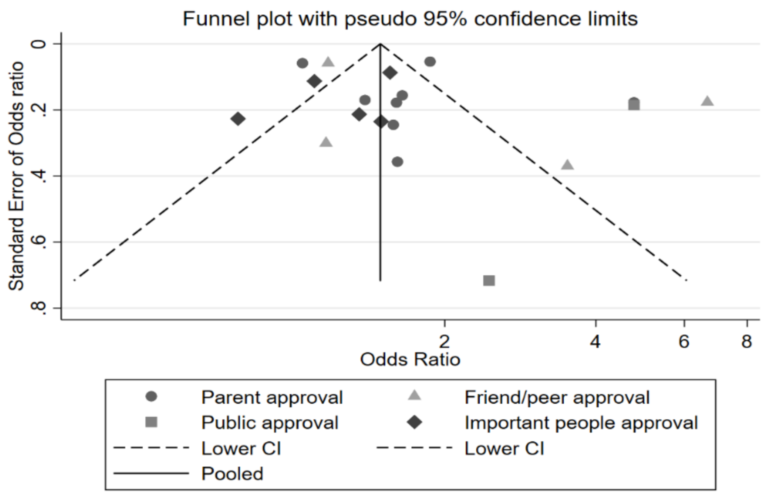
A non-parametric trim and fill method was used to assess whether correcting for publication bias influences the results [190, 191]. The overall effect estimate for the association between descriptive norms and smoking initiation was reduced slightly after correcting for publication bias but remained significant (before trim and fill: OR=1.88 [1.65-2.13]; after trim and fill: OR=1.60 [1.42-1.82]). The overall effect estimates for the associations between injunctive norms (before trim and fill: OR=1.78 [1.43-2.21]; after trim and fill: OR=1.78 [1.43-2.21]) and perceived pressure to smoke (before trim and fill: OR=1.15 [0.91-1.46]; after trim and fill: OR=1.10 [0.87-1.38]) and smoking initiation were relatively unchanged after correcting for publication bias.

Figure 2.5. Funnel plots of the associations between (a) descriptive norms, (b) injunctive norms, and (c) perceived pressure to smoke and youth smoking initiation, grouped by social group

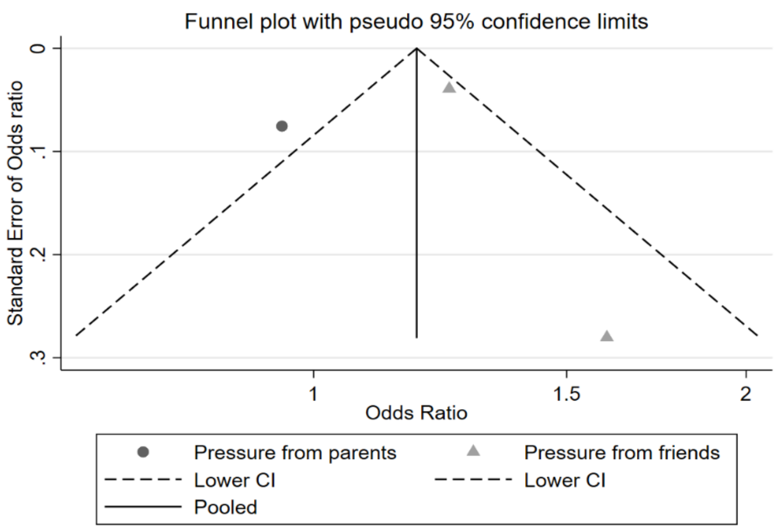
a)



b)



c)



2.5. Discussion

This systematic review and meta-analysis synthesised evidence and provided summary estimates of the associations between social norms towards smoking and youth smoking initiation. Overall, when pooling unadjusted associations via meta-analyses, I found that perceiving that others smoke (descriptive norms) and that others approve of smoking (injunctive norms) had a strong, positive effect on youth smoking initiation, although the strength and reliability of associations was not consistent across social groups. However, in the overall systematic review I found that injunctive norms had a less consistent effect on smoking initiation and escalation when adjusting for covariates.

Smoking among parents, siblings, family, and close friends all had a strong and reliable effect on youth smoking initiation, consistent with findings from previous reviews and meta-analyses [96, 97, 99]. The meta-analysis pooling unadjusted associations found that close friend and sibling smoking had the strongest effect on youth smoking, both more than doubling the odds of smoking initiation. The effect sizes for parent and sibling smoking were similar to those found in previous research [96]. Perceived adult smoking prevalence had a small but positive effect on youth smoking initiation, while perceived peer prevalence of smoking had no reliable effect when pooling unadjusted associations. Taken together, my findings suggest that the smoking behaviour of one's close social groups have a greater effect on youth smoking initiation than perceptions of how common smoking is among peers or adults. This reflects the findings of a seminal study exploring the dynamics of smoking in a large social network [95] and theories proposing that the smoking behaviours of those closest to you are stronger predictors of behaviour than the smoking behaviours of wider social groups [58, 73, 76].

Considering injunctive norms, I found that perceiving that parents approve of smoking had a strong and reliable effect on youth smoking initiation in the meta-analysis pooling unadjusted associations, increasing the odds of smoking initiation by 1.7 times. However, several studies in the narrative synthesis found that parent approval of smoking was only associated with smoking initiation and escalation in unadjusted analyses, but when adjusting for other measures of smoking norms (including parent/family smoking) this association dissipated [104, 202, 207]. One study further found that perceiving that parents disapprove of smoking was protective against smoking initiation and escalation among youth with non-smoking parents but not smoking parents [195]. It is therefore possible that the apparent associations between perceived parent approval of smoking and youth smoking from the meta-analysis are confounded by, or dependent upon, the smoking behaviour of parents. At the very least my findings suggest that the smoking behaviour of close others is a more consistent predictor of youth smoking initiation than perceptions of close others' approval of smoking. This is consistent with a previous meta-analysis, which found that descriptive norms are stronger correlates of behaviours than injunctive norms [90]. It is also consistent with meta-analyses that had found descriptive and injunctive norms to be distinct predictors of behaviour [89, 90].

I found that perceiving that friends/peers approve of smoking was not reliably associated with youth smoking initiation. For this systematic review and meta-analysis, I grouped close friend and peer injunctive norms together because they were combined in most articles included. Grouping these norms together may have concealed individual effects of perceived friend, or peer, approval on youth smoking initiation. However, there did not appear to be much difference in the results of articles that only assessed close friend approval and those that combined close friend approval with peers (classmates/people your age) approval. These findings again suggest that injunctive norms may not necessarily have a reliable influence on youth smoking initiation.

I also found that perceiving that the public approve of smoking had a strong positive effect on youth smoking initiation when pooling unadjusted associations. However, estimates were only based on two studies, one of which had wide confidence intervals [1]. In the narrative synthesis I also found that the one study reporting evidence of associations in unadjusted analyses did not find associations when adjusting for covariates. Studies in this field should continue to assess perceived public approval of smoking so that more reliable conclusions can be drawn regarding its effect on youth smoking initiation.

I found that perceiving pressure to smoke from friends/peers was reliably and positively associated with youth smoking initiation when pooling the unadjusted associations from two studies via a meta-analysis. However, the results from the systematic review suggest that this association may be less reliable when adjusting for covariates. Perceiving pressure to smoke from parents also did not show a reliable association with youth smoking initiation in either the systematic review or meta-analysis, although there were few studies assessing this measure measures. Similar to societal-level injunctive norms, studies should continue to assess the effect of perceived pressure to smoke on youth smoking initiation to allow more reliable conclusions to be drawn.

My findings for escalation of smoking were broadly similar to my findings for initiation in the systematic review. This suggests that social norms may have a similar influence on initiation of smoking among never smoking youth as escalation of smoking among youth who had already initiated smoking. However, there was considerable heterogeneity across outcomes of smoking escalation. For example, some articles assessed initiation of at-least-weekly smoking [202, 211], some assessed increases in cigarettes per day or per week [92, 193, 199], and some assessed trajectories of smoking [201, 203, 208]. More studies using similar outcomes of escalation to regular smoking (e.g., weekly or daily smoking) are required, so that meta-analyses can synthesise evidence of associations with social norms and advance knowledge in this area.

Interestingly, in the meta-regression I found that perceived peer smoking prevalence had a smaller effect on youth smoking initiation than parent smoking, consistent with my findings from the meta-analyses. However, except perceived peer approval of smoking, the meta-regression did not indicate much variation in effect sizes across the different types of social norm. Meta-regressions are often limited by lack of statistical power which can result in failure to detect associations. Further, while 58 associations were included overall, the number of associations were low for some social norms (e.g., only two associations for perceived public approval of smoking). Further research assessing the associations between different smoking norms and youth smoking initiation is required so that these meta-analyses and meta-regressions can be replicated and extended.

My findings may have important implications for theories of smoking behaviour. Social Cognitive Theory and PRIME (Plans, Responses, Impulses, Motives, Evaluations) Theory of addiction both state that social norms, particularly from close social groups, predict behaviour [58, 73, 76]. Similarly, the Theory of Planned Behaviour posits that injunctive norms, particularly those from important others, determine intention to engage in a behaviour which in turn predicts the behaviour itself [66]. Descriptive norms are also important to consider as an additional distinct component of the Theory of Planned Behaviour [89, 90]. Social norms towards smoking are often also placed on the pathway between tobacco control policies and changes in smoking behaviour [58-62]. The results from this systematic review and meta-analysis broadly support these theories, to the extent that the descriptive norms of close social groups are most strongly predictive of youth smoking initiation. However, injunctive norms and the descriptive norms of wider social groups appear to have less of a reliable influence than the descriptive norms of close others. Theories may therefore benefit from distinguishing between the descriptive and injunctive norms of different social groups to enhance their predictive utility.

Interestingly, I found the effects of smoking norms on smoking initiation to be stronger among studies from Asia than the US or Europe. This could be attributable to differences in sampling methods or survey design; however, the two studies using samples from Asia did not appear substantially different from the US or European studies. Further, in the meta-regression I found no other sample or study design characteristic to be associated with variation in the effect size. Some countries in Asia are at an earlier stage of the tobacco epidemic compared to the US and Europe [222]. Previous research also suggests that social norms may play a different role in predicting smoking behaviour in different cultural contexts and in countries with different tobacco control policies and smoking prevalence rates [94]. For example, perceiving that people important to you believe you should not smoke has been found to be associated with intending to quit smoking in Malaysia, the UK, Canada, the US, and Australia, but not

Thailand [94]. Future research should consider the associations between smoking norms and smoking initiation among youth across countries with different tobacco control policies to help understand these findings.

2.5.1. Limitations

My findings must be considered in light of several limitations. First and foremost, studies that only included measures of descriptive norms within one's close social circle (i.e., family and close friends) were excluded from the systematic review. This was because of the vast number of studies identified only assessing these norms and because there had already been reviews synthesising evidence on their associations with youth smoking initiation [96, 97]. However, friend and family smoking were still the most frequently assessed norms. Further, the effect sizes for parent and sibling smoking were similar to those found in previous meta-analyses [96]. This inclusion criteria would also not have had an influence on the results of the societal-level or injunctive norms.

Second, there was substantial evidence of risk of bias both within and between studies. Over two thirds of articles were of low quality, although, surprisingly, low study quality was associated with a smaller effect size. There was also evidence of publication bias, which may have influenced the results. However, trim and fill correction of publication bias did not change the interpretation of the results. These findings suggest little cause for concern regarding study quality and bias.

Third, as mentioned above, some social norms measures were grouped together for analyses (e.g., friend and peer approval, approval from people important to you). My findings suggest that the perceived approval of smoking among different social groups may have a different influence on youth smoking initiation and escalation. Therefore, grouping the norms of different social groups together may reduce the predictive utility of these measures.

2.5.2. Strengths

My study has important strengths. It was the first systematic review and meta-analysis to assess the effects of different social groups' smoking norms on youth smoking initiation, providing a novel and important contribution to the literature. The search was not limited to peer-reviewed publications in an attempt to minimise publication bias; theses and other unpublished works were eligible for inclusion, and were sought from authors where they were not publicly available. The studies included were all longitudinal, with the vast majority (35/41) running for three years or more. Further, most (25/41) had sample sizes of over 1,000 respondents, enhancing statistical power. Finally, random effects meta-analyses were used to account for heterogeneity and were only used to pool data with similar outcomes of smoking initiation. A meta-regression was also used to explore potential sources of heterogeneity.

2.5.3. Conclusions

In this systematic review and meta-analysis, I found that overall perceiving that others smoke (descriptive norms) had a strong, positive effect on youth smoking initiation. However, when split by social group, family and friend smoking had the strongest and most reliable effect on youth smoking initiation, perceived prevalence of smoking among adults had a small but reliable effect, and perceived prevalence of smoking among peers had no reliable effect. I also found that, overall, perceiving that others approve of smoking (injunctive norms) had a strong, positive effect on youth smoking inhiation. However, when split by social group, only perceived approval of smoking among parents and the public, but not friends/peers or people important to you, had a strong and reliable effect on youth smoking initiation. Moreover, when adjusting for covariates it appeared that these injunctive norms had a less consistent effect on youth smoking.

2.6. Impact and dissemination

This work is being prepared for submission to an academic journal. I presented my preliminary findings as an oral presentation in symposium that I organised on social norms, at the Society for Research on Nicotine and Tobacco (SRNT) 2018 Annual Meeting in Baltimore, US (presentation available online at [9]).

CHAPTER 3

Survey Methodology Used in Chapters 4-8

3.1. Preface

Chapter 3 describes the survey research methods used in each of my publications in Chapters 4-8 [1-5]. My publications in Chapters 4-8 used data from five surveys [1-5]:

> Chapter 4 and Chapter 5 use data from two surveys among British youth led by Action on Smoking and Health (ASH): the 2016 ASH Great Britain Longitudinal Youth Survey (Chapter 4 [1]) and the 2016 ASH Great Britain Smokefree Youth Survey (Chapter 5 [2]).
>
> Chapter 6, Chapter 7, and Chapter 8 use data from three international surveys led by the International Tobacco Control Policy Evaluation (ITC) Project, one among youth: the 2017 ITC Project Youth Survey (Chapter 6; England, Canada, US [3]), and two among adults: the 2016 ITC Project Europe Surveys (Chapter 7; Romania, Spain, Hungary, Poland, Greece, Germany, England [4]) and the 2002-2015 ITC Four Country Survey (Chapter 8; UK, Canada, US, Australia [5]).

Because this thesis incorporates publications, more detailed information on the methods can also be found in the published articles in each Chapter [1-5].

3.2. ASH Surveys

Chapter 4 and Chapter 5 use data from two surveys led by ASH [1, 2].

ASH is a public health charity that campaigns to eliminate the harm caused by tobacco. ASH conducted two surveys among youth in 2016: the 2016 ASH Great Britain Longitudinal Youth Survey, a longitudinal online survey of British youth, and the 2016 ASH Great Britain Smokefree Youth Survey, a separate annual cross-sectional online survey of British youth age 11-18. These surveys were designed to be nationally representative of youth in Great Britain and measure a wide range of smoking and vaping attitudes and behaviours.

3.2.1. 2016 ASH Great Britain Longitudinal Youth Survey, used in Chapter 4

The 2016 ASH Great Britain Longitudinal Youth Survey was an online longitudinal survey of youth age 11-18 in Great Britain. The first survey was in the field between 6th and 20th April 2016, and the follow-up survey was in the field approximately four to six months later between 5th August and 7th October 2016. The sample was drawn from an online survey panel of the general public maintained by Ipsos MORI. This survey was implemented with the aim of assessing the longitudinal association between vaping and smoking among British youth.

Respondents were recruited by Ipsos MORI using a non-probability quota sampling approach. Quotas were set in respect of age, gender, and Government Office Region (GOR) using data from the Eurostat 2012, to ensure the sample was representative of youth age 11-18 in Great Britain. Respondents age 16-18 were recruited directly from the online panel via an email informing them of the survey and inviting them to take part. Respondents age 11-15 were recruited via emails to parents or legal guardians on the online panel, asking them to read the information about the survey and pass it on to their child. Those giving consent were asked to follow a link to the survey online. To maximise follow-up rates, up to eight email reminders were sent to all respondents, and the follow-up survey period lasted for two months. Each survey took approximately 10 minutes to complete, and financial incentives were provided via a prize draw.

3.2.1.1. Weighting

Survey weights were incorporated to enhance representativeness of the sample to youth age 11-18 in Great Britain. Weights were calculated by Ipsos MORI based on age, gender and GOR, and were calibrated using data from the Eurostat 2012.

3.2.1.2. Ethics

Ipsos MORI adheres to the European Society for Opinion and Marketing Research (ESOMAR) code of conduct for online panels [223]. All respondents were provided with information about the study and asked to provide consent before participating. For those respondents age 11-15, informed consent was also required from their parent(s) or guardian(s). This research involved secondary data analysis of an existing anonymous/deidentified dataset maintained by Ipsos MORI and ASH. King's College London's Research Ethics Office confirmed further ethical approval was not required.

3.2.2. 2016 ASH Smokefree Great Britain Youth Survey, used in Chapter 5

The ASH Smokefree Great Britain Youth Surveys are online annual cross-sectional surveys of youth age 11-18 in Great Britain, with approximately 2,000 respondents per year. For this research only data from the 2016 survey were used, which was in the field between 11th March and 10th April 2016. The sample was drawn from an online survey panel of the general public maintained by YouGov [224]. The ASH Smokefree Great Britain Youth Surveys were implemented with the aim of monitoring and evaluating smoking and vaping behaviours and attitudes among British youth.

Respondents were recruited by YouGov using a non-probability quota sampling approach. Quotas were set in respect of age, gender, and GOR using data from 2015 Office for National Statistics census data, to ensure the sample was representative of youth age 11-18 in Great Britain. Respondents age 16-18 were recruited directly from the online panel via an email informing them of the survey and inviting them to take part. Respondents age 11-15 were recruited via emails to parents or legal guardians on the online panel, asking them to read the information about the survey and pass it on to their child. Parents with more than one child were requested to pass the survey to their child whose birthday was coming up next (next birthday method) [225]. Those giving consent were asked to follow a link to the survey online. Each survey took approximately 10 minutes to complete. Modest financial incentives were provided in return for completing the survey: 50p for those aged 16-18, and £1.50 for those aged 11-15.

3.2.2.1. Weighting

Survey weights were incorporated to enhance representativeness of the sample to youth age 11-18 in Great Britain. Weights were calculated by YouGov based on age, gender and GOR, and were calibrated using 2015 Office for National Statistics census data.

3.2.2.2. Ethics

YouGov adheres to the Market Research Society code of conduct for online panels [226]. All respondents were provided with information about the study and asked to provide consent before participating. For those respondents age 11-15, informed consent was also required from their parent(s) or guardian(s). As above, this research involved secondary data analysis of an existing anonymous/deidentified dataset maintained by YouGov and ASH. King's College London's Research Ethics Office confirmed further ethical approval was not required.

3.3. ITC Project Surveys

Chapter 6, Chapter 7, and Chapter 8 use data from three surveys led by the ITC Project [3-5].

The ITC Project was established in 2002 to monitor and evaluate key health policies implemented in countries that ratified the Framework Convention on Tobacco Control (FCTC) [23, 60]. The ITC Project conducts longitudinal surveys of nationally representative cohorts of smokers (and vapers and ex-smokers in some surveys) in over 28 countries. These surveys measure a wide range of smoking attitudes and behaviours and, more recently, vaping attitudes and behaviours. This research used data from the ITC Youth Tobacco and Vaping Survey (England, Canada, US), the adult ITC Europe Surveys (Romania, Spain, Hungary, Poland, Greece, Germany, England) and the adult ITC Four Country Survey (UK, Canada, US, Australia).

3.3.1. 2017 ITC Youth Tobacco and Vaping Survey used in Chapter 6 (England, Canada, US)

The 2017 ITC Youth Tobacco and Vaping Survey is an online longitudinal survey of youth age 16-19 in England, Canada, and the US [227]. This survey aims to understand the factors that predict vaping initiation among youth and to examine policy measures that may prevent vaping initiation among non-smokers [227].

For this research, only data from the Wave 1 survey were used, which was in the field between July and August 2017. The 2017 ITC Youth Tobacco and Vaping Survey sample was recruited via an online survey panel of the general public maintained by Nielsen Consumer Insights Global Panel.

Respondents were recruited by Nielsen using a combination of probability and non-probability sampling methods in each country. Random samples were selected from the online panels in each country, with targets of 4,500 respondents in each of England, Canada and the US. Email invitations were sent to a random sample of panellists age 16-19 only. Panellists known to be parents were also contacted, and those who confirmed having a child aged 16-19 in their household were asked for permission for one eligible child to complete the survey. Parents were asked to select the child using the next birthday method of selection [225]. A restriction on small screen size was applied so that respondents attempting to complete the survey on a mobile device were ineligible to partake. The survey was administered in English, as well as French in Canada, and took approximately 15 minutes. Incentives for completing the survey were provided according to each country's panel incentive structure: either monetary or points-based rewards, which could be redeemed for catalogue items, as cash, a donation, and/or chances to win monthly prizes. Further information on the design and sample is available in the 2017 ITC Youth Tobacco and Vaping Survey Technical Report [227].

3.3.1.1. Weighting

Survey weights were incorporated to enhance representativeness of the sample to youth age 16-19 in each country. Weights were calculated by the ITC Data Management Core Support Team at the University of Waterloo based on age, gender, race/ethnicity, region, language (Canada only) and smoking status. Calibration frequencies were obtained from the 2016 Opinions and Lifestyle Survey (England), the 2015 Canadian Tobacco Alcohol and Drugs Survey (Canada), and the 2015 National Youth Tobacco Survey (age 16-17; US) and 2013-14 National Adult Tobacco Survey (18-19; US). Weights were rescaled to each country's sample size. Further information on the weighting procedures are available elsewhere [227].

3.3.1.2. Ethics

Nielsen's online panels adhere to the Nielsen Code of Conduct [228]. All respondents were provided with information about the study and asked to provide consent before participating, including permission for researchers to use their data. For those respondents who were recruited through their parents, informed consent was also required from their parent(s) or guardian(s) as stated above. The 2017 ITC Youth Tobacco and Vaping Survey was approved by the University of Waterloo Research Ethics Committee (ORE#21847) and the King's College London Psychiatry, Nursing & Midwifery Research Ethics Subcommittee (PNM-RESC#HR-16/17-4113).

3.3.2. 2016 ITC Europe Surveys used in Chapter 7 (Romania, Spain, Hungary, Poland, Greece, Germany, England)

The 2016 ITC Europe Surveys included in this research consist of the 2016 ITC Six European Country Survey (part of the European Regulatory Science on Tobacco: Policy Implementation to Reduce Lung Disease (EUREST-PLUS) Project [59, 229, 230]) and the England arm of the 2016 ITC Four Country Smoking and Vaping Survey [231]. The EUREST-PLUS Project aims to examine the prevalence and patterns of tobacco use, and to monitor and evaluate the impact of the 2014 European Union (EU) Tobacco Products Directive (TPD) [53] and ratification of the FCTC [23] at the European level.

3.3.2.1. 2016 ITC 6 European Country Survey (Romania, Spain, Hungary, Poland, Greece, Germany)

The 2016 ITC Six European Country Survey was a face-to-face survey of adult smokers age 18+ in Romania, Spain, Hungary, Poland, Greece, and Germany. For this research, only data from the Wave 1 survey were used, which was in the field from 16th June to 12th September 2016. The fieldwork was managed and coordinated by Kantar Public Brussels and administered by the following National Agencies: Curs (Romania), Kantar Taylor Nelson Sofres (TNS) Spain (Spain), Kantar TNS Hoffman (Hungary), Kantar TNS Polska (Poland), Metron Analysis (Greece), Foerster and Thelen (Germany).

Respondents were recruited via a face-to-face multi-stage stratified random sample of current smokers age 18+, designed to yield nationally representative samples of adult current smokers in each country. Households for the 2016 ITC Six European Country Survey were selected via stratified random sampling. Each country was divided into Nomenclature of Territorial Units for Statistics (NUTS) regions, except Germany where NUTS2 regions were used, and each NUTS region was crossed with degree of urbanisation (urban, intermediate, rural) to form strata. Within each stratum, clusters were allocated proportionally to population sizes of adults (age 18+), requiting at least two clusters per stratum. Clusters were then selected at random within each stratum. For recruitment, targets were set of 100 clusters per country and 10 adult smokers per cluster, totalling 1,000 adult smokers per country. A random walk method was used to select households within each cluster, with a starting point allocated at random using GPS (Global Positioning System) coordinates and a random walk path pre-drawn on a tablet. The interviewers were to follow the path and approach every fifth address on that path. For each chosen address, contact was attempted up to four times.

Interviewers approached a household and administered a household-level screener survey to the “most knowledgeable individual”. Eligible household members comprised those age 18+ who smoked cigarettes at least monthly and had smoked over 100 cigarettes in their lives, and up to one eligible male and female were selected using the last birthday method of selection for each (the respondent whose birthday was the most recent). Eligible and consenting respondents were screened to confirm their age and smoking status, and those eligible were administered the full survey. Interviews took approximately 35 minutes. Screening and interviewing of households continued until the required number of smokers (n=10) from the cluster had been interviewed.

The survey was finalised in English and translated into each country's language by Kantar Public Brussels in three steps: (1) survey translated by an independent translator, (2) translated survey revised by an independent proof-reader, (3) translated survey revised by the project manager of the National Agency within that country. The interviewers administered the survey in the national language of each of the six participating countries. Remuneration for completing the survey was provided to each respondent based on the National Agency used in each country (€3 Spain, €5 Greece, €7 Romania, €10 Hungary, Poland and Germany). Further information on the design and sample is available elsewhere [59, 230, 232].

3.3.2.2. 2016 ITC Four Country Smoking and Vaping Survey (England only)

The 2016 ITC Four Country Smoking and Vaping Survey was part of a larger longitudinal online survey of adult smokers age 18+ in England, Canada, the US and Australia (see Section 3.3.3 below). For this research, only data from Wave 1 of the ITC Four Country Smoking and Vaping England Survey were used, which was in the field from 11th July to 29th November 2016. The sample consisted of: (1) re-contacted smokers and quitters who participated in the previous Wave of the ITC Four Country Project, or (2) newly recruited current smokers and recent quitters (quit smoking in the past 24 months) or current vapers (use at least weekly).

The re-contacted respondents had been initially recruited via probability-based random-digit-dialling sampling frames and were managed either by the University of Waterloo's Survey Research Centre or the survey firm that was responsible for storing their data. The newly recruited smokers were drawn from Ipsos MORI's online survey panel using quotas set on gender, age and GOR using data from the 2015 Opinions and Lifestyle Survey [233]. The sample was therefore designed to be nationally representative of adult current smokers in England.

All respondents completed the survey through an online questionnaire hosted by the University of Waterloo's Survey Research Centre. Recontact smokers received financial incentives in the form of a £16 Amazon e-gift card. Newly recruited respondents managed by Ipsos MORI received financial incentives in the form of points equivalent to £20 (age 18-24) or £16 (age 25+). Further information on the design and sample is available elsewhere [231].

3.3.2.3. Weighting

Survey weights were incorporated to enhance representativeness of the sample to current smokers age 18+ in each country. Weights were calculated by the ITC Data Management Core Support Team at the University of Waterloo based on gender, age, stratum based on NUTS region and degree of urbanisation (Six European Country Survey) or GOR (England Survey), probability of selection within a given household (Six European Country Survey only), and smoking and vaping status (England Survey only). Calibration frequencies were obtained from the 2014 Eurobarometer Survey (Six European Country Survey) or the 2015 Opinions and Lifestyle Survey (England Survey). Weights were rescaled to each country's sample size. Further information on the weighting procedures are available elsewhere [231, 232].

3.3.2.4. Ethics

The survey firms for the ITC Europe Surveys have their own ethical procedures. For example, Ipsos MORI adheres to the ESOMAR code of conduct for online panels [223]. All respondents were provided with an information sheet and asked to provide consent before participating. The 2016 ITC Europe Surveys were approved by the University of Waterloo Research Ethics Committee (Six European Country Survey: ORE #21262; England Survey: ORE#20803/30709) and the King's College London Psychiatry, Nursing & Midwifery Research Ethics Subcommittee (England Survey: IRB-RESCM#17/18-2240).

3.3.3. 2002-2015 ITC Four Country Survey used in Chapter 8 (UK, Canada, US, Australia)

The ITC Four Country Survey is a nine Wave longitudinal survey of adult smokers and ex-smokers age 18+. The first Wave began in 2002 and the final Wave was completed in 2015. In 2016, the ITC Four Country Survey was developed into the ITC Four Country Smoking and Vaping Survey (see Section 3.3.2.2). For this study, data from Waves 1 (2002) to 9 (2013-2015) of the ITC Four Country Survey were used. The ITC Four Country Survey aims to monitor and evaluate key tobacco control policies implemented in countries that ratified the FCTC [23, 60].

The 2002-2015 ITC Four Country Survey sample was recruited via probability-based random-digit-dialling sampling frames within each stratum defined by geographic region and community size. Within each country, the sample was stratified geographically, such that quotas were assigned to the numbers of respondents in each of several regions. The numbers in the sampling frame, randomly ordered, were called until these quotas were met. Targets of approximately 2,000 respondents in each country were set for each Wave.

At the first contact, respondents were screened for eligibility and to ascertain consent through a 10-minute phone call. Eligible household members comprised those age 18+ who smoked cigarettes at least once in the past 30 days and had smoked over 100 cigarettes in their lives. Up to one eligible individual was selected using the next birthday method of selection in each household. Those eligible and who consented were then re-contacted to complete the main survey, which took approximately 35 minutes to complete. All respondents were re-contacted with an invitation to participate in the next Wave irrespective of their smoking status. Waves 1-6 were administered used Computer Assisted Telephone Interviewing (CATI), while Waves 7-9 were administered using a combination of CATI and online surveys. To replenish the sample and offset loss to attrition, new smokers were recruited at every Wave in every country. The interviewers administered the surveys in English, except in Canada where surveys were in English or French. Remuneration for completing the survey was provided to each respondent: Wave 1-6 was $15AUD, $15CDN, $10USD, or a £7 Boots voucher (a UK health and beauty shop), Wave 6 onwards was $15 (Canada, US, Australia) or £10 (UK). Further information on the design and sample is available elsewhere [234-236].

3.3.3.1. Weighting

Survey weights were incorporated to enhance representativeness of the sample to adult smokers age 18+ in each country. Weights were calculated by the ITC Data Management Core Support Team at the University of Waterloo based on gender, age, and region, and were calibrated using national benchmark surveys for each year and country. Weights were rescaled to each country's sample size. The rescaled cross-sectional weights at each Wave were used for my publication in Chapter 8 of this thesis (i.e. not adjusted for attrition). Wave 1 to Wave 9 longitudinal weights were not calculated because few respondents were retained through all Waves. Further information on the weighting procedures are available elsewhere [234-236].

3.3.3.2. Ethics

All respondents were provided with information about the study and were asked to provide consent before participating. The 2002-2015 ITC Four Country Survey was approved by the Institutional Review Boards or Research Ethics Boards in each of the countries: The University of Waterloo (Canada), Roswell Park Cancer Institute (US), The University of Illinois-Chicago (US), The University of Strathclyde (UK), The University of Stirling (UK), The Open University (UK), King's College London (UK), and Cancer Council Victoria (Australia).

3.4. Measures used in each Chapter

All of the surveys used in this thesis included measures of social norms. The measures used in both of the ASH surveys, the ITC Youth Tobacco and Vaping Survey, and the ITC Europe Surveys were informed by my previous work [15]. The number and wording of the social norms measures vary across each survey and Chapter because only a limited number of measures could be included in each survey and measures were modified during discussions with the ASH and ITC Project teams and survey companies. The outcomes and covariates adjusted for also varied across Chapters due to availability in each survey. Where possible, covariates were kept consistent across Chapters and were selected based on previous research assessing norms [15, 100, 113, 149, 152, 154, 237] and predictors of youth smoking behaviour [99, 144, 158].

Table 3.1 summarises the measures used in each Chapter. Because this thesis incorporates publications, more detailed information on the measures used can be found in the publications in each Chapter.

Table 3.1. Measures used in each of Chapters 4-8

	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8
Sample		**Youth**		**Adult smokers²**	
Social norms					
Smoking					
Family smoking	✓	✓			
Friend smoking	✓	✓	✓*	✓*	✓*
Important people's approval				✓*	✓*
Peer approval			✓*		
Public approval	✓	✓		✓*	✓*
Smokers are marginalised¹				✓*	
Opinion of smoking¹					✓*
Vaping					
Family vaping	✓	✓			
Friend vaping	✓		✓*	✓*	
See vaping in public				✓*	
Peer approval			✓*		
Public approval	✓	✓		✓*	
Behaviours					
Smoking and vaping initiation	✓*				
Smoking and vaping status		✓	✓	✓	
Harm perceptions					
Vaping relative to smoking		✓*			
Nicotine relative to smoking		✓*			
Policies and prevalence rates					
Country			✓	✓	✓
Time					✓
Covariates					
Smoking and vaping susceptibility	✓				
Smoking dependence				✓	✓
Age	✓	✓	✓	✓	✓
Gender	✓	✓	✓	✓	✓
Socio-economic status		✓	✓	✓	✓
Ethnicity			✓		✓
Student status			✓		
School performance	✓				
Problem behaviour	✓				
Alcohol use	✓		✓		
Marijuana use			✓		
Region lived in		✓			
Survey design effects					✓

¹ Agreeing that smokers are marginalised and opinion of smoking are not social norms according to the definition in this thesis, but attitudes such as these have been found to correlate well with social norms [66, 93, 238]. These measures were therefore included to complement the social norms measures. ² Chapter 8 is among adult *daily* smokers only. *=Measured as the outcome.

CHAPTER 4

Smoking and Vaping Initiation and Norms Among British Youth

4.1. Preface

There are concerns that vaping may attract never smoking youth into nicotine use and smoking, and also that vaping might renormalise smoking [35, 48-56]. During the first year of my PhD, evidence was emerging from the US and Great Britain that vaping among never smoking youth was associated with subsequent smoking initiation [146-155, 157]. Studies among youth in the US and Argentina also found that smoking was associated with subsequently initiating vaping [154, 159]. It is therefore possible that there is a reciprocal association between use of both products. However, the association between both vaping and smoking initiation, and smoking and vaping initiation, had not been explored among British youth.

Prior to my PhD, little was also known about whether vaping norms predict youth vaping initiation. Additionally, little was known about whether smoking norms predict vaping initiation and vaping norms predict smoking initiation which should be expected if vaping has the potential to renormalise smoking.

In this Chapter I therefore addressed the following objectives: assess the longitudinal associations between (i) vaping and smoking initiation, (ii) smoking and vaping initiation, (iii) smoking and vaping norms and smoking initiation, and (iv) smoking and vaping norms and vaping initiation among a nationally representative sample of British youth age 11-18.

These objectives relate to *Aims 1-4* of my thesis: To assess, among youth, the associations between smoking norms and smoking behaviours *(Aim 1)*, vaping norms and vaping behaviours *(Aim 2)*, vaping norms and smoking behaviours, and smoking norms and vaping behaviours *(Aim 3)* and vaping initiation and smoking initiation *(Aim 4)*.

I addressed these objectives, and hence thesis aims, in my first peer-reviewed publication, which is presented in Section 4.2 below [1]:

> *East, K., Hitchman, S. C., Bakolis, I., Williams, S., Cheeseman, H., Arnott, D., & McNeill, A. (2018). The association between smoking and electronic cigarette use in a cohort of young people. Journal of Adolescent Health, 62(5), 539-547, doi: 10.1016/j.jadohealth.2017.11.301.*

In my publication [1] I focussed on (i) and (ii) above; I also assessed (iii) and (iv) but did not discuss them in the publication because of limited word count. I have therefore discussed the social norms findings (iii) and (iv) below the publication, in Section 4.3. I have also included a summary of the impact and dissemination of this work, in Section 4.4.

The supplementary materials referred to in my publication [1] are available in Appendix G of this thesis.

4.1.1. Declaration of roles

I developed this publication [1] in collaboration with Dr Sara C Hitchman, Professor Ann McNeill, and Dr Ioannis Bakolis (King's College London), Sarah Williams, Hazel Cheeseman, and Deborah Arnott (Action on Smoking and Health [ASH]), and the survey firm Ipsos MORI. SW, HC, DA, and Ipsos MORI designed the survey. Ipsos MORI were responsible for sample recruitment and maintenance. SCH, AM, and I provided input on the survey design and measures, particularly the smoking and vaping norms measures which were informed by my previous work [15]. IB provided statistical support, particularly in running causal mediation analyses. I led the write-up of this publication [1], formulated the research questions, and analysed the data, with input from SCH and AM. IB provided input on the analyses, and all co-authors reviewed and provided input on drafts of the publication.

4.1.2. Selection of social norms measures

In my publication [1] I used data from the 2016 ASH Great Britain Longitudinal Youth Survey. I selected four measures of smoking norms and four measures of vaping norms for use in this publication [1]: parent smoking, sibling smoking, friend smoking, perceived public approval of smoking, parent vaping, sibling vaping, friend vaping, and perceived public approval of vaping (see Table 3.1).

I selected these eight social norms measures because they covered a range of social groups and covered both descriptive and injunctive norms. Perceived societal approval of smoking and vaping were included specifically because my preliminary findings from the systematic review in Chapter 2 suggested that more research on societal-level injunctive norms was needed. I could not assess a wider range of social norms measures because there were constraints on the number of measures that could be included in the ASH Great Britain Longitudinal Youth Survey. The inclusion and wording of all social norms measures in the ASH Great Britain Longitudinal Youth Survey were based on discussions with co-authors, ASH, and the survey firm Ipsos MORI. The wording of some social norms measures in this Chapter therefore differed from other Chapters in this thesis.

4.2. Publication

Journal of Adolescent Health 62 (2018) 539–547

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Original article

The Association Between Smoking and Electronic Cigarette Use in a Cohort of Young People

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A B S T R A C T

Purpose: Electronic cigarette (e-cigarette) use is associated with smoking initiation among young people; however, it is also possible that smoking is associated with e-cigarette initiation. This study explores these associations among young people in Great Britain.
Methods: A longitudinal survey of 1,152 11- to 18-year-olds was conducted with baseline in April 2016 and follow-up between August and October 2016. Logistic regression models and causal mediation analyses assessed whether (1) ever e-cigarette use and escalation were associated with smoking initiation (ever smoking at follow-up) among baseline never smokers (n = 923), and (2) ever smoking and escalation were associated with e-cigarette initiation (ever e-cigarette use at follow-up) among baseline never e-cigarette users (n = 1,020).
Results: At baseline, 19.8% were ever smokers and 11.4% were ever e-cigarette users. Respondents who were ever e-cigarette users (vs. never users, 53% vs. 8%, odds ratio [OR] = 11.89, 95% confidence interval [CI] = 3.56–39.72) and escalated their e-cigarette use (vs. did not, 41% vs. 8%, OR = 7.89, 95% CI = 3.06–20.38) were more likely to initiate smoking. Respondents who were ever smokers (vs. never smokers, 32% vs. 4%, OR = 3.54, 95% CI = 1.68–7.45) and escalated their smoking (vs. did not, 34% vs. 6%, OR = 5.79, 95% CI = 2.55–13.15) were more likely to initiate e-cigarette use. There was a direct effect of ever e-cigarette use on smoking initiation (OR = 1.34, 95% CI = 1.05–1.72), and ever smoking on e-cigarette initiation (OR = 1.08, 95% CI = 1.01–1.17); e-cigarette and smoking escalation, respectively, did not mediate these effects.

IMPLICATIONS AND CONTRIBUTION

This study employs a causal inference approach to provide further support for the association between ever e-cigarette use and smoking initiation, and additionally finds that ever smoking is associated with e-cigarette initiation, among young people.

Conflicts of Interest: Katherine East, Sara Hitchman, and Ann McNeill are members of the UK Centre for Tobacco and Alcohol Studies. Ioannis Bakolis is supported by the National Institute for Health Research (NIHR) Biomedical Research Centre at South London and Maudsley NHS Foundation Trust and by the NIHR Collaboration for Leadership in Applied Health Research and Care South London at King's College Hospital NHS Foundation Trust. Sarah Williams is an employee at Public Health England and was previously an employee at Action on Smoking and Health at the time this study was conducted. Hazel Cheeseman and Deborah Arnott are employees of Action on Smoking and Health, which receives funding from the British Heart Foundation, Cancer Research UK (CRUK), and the Department of Health. This study was funded by CRUK grant code A21559. CRUK was not involved in the study design, data collection, analysis or interpretation of the data, the write up of the manuscript, or decision to submit the article for publication. The views expressed are those of the author(s) and not necessarily those of Public Health England, CRUK, Action on Smoking and Health, the NHS, the NIHR or the Department of Health.

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Conclusions: Among young people in Great Britain, ever e-cigarette use is associated with smoking initiation, and ever smoking is associated with e-cigarette initiation.

There are an estimated 2.9 million current adult electronic cigarette (e-cigarette) users in Great Britain [1]. Concerns have been expressed about the impact of e-cigarette use on cigarette smoking, particularly among young people [2–4]. There is some evidence that trial of e-cigarettes among young people aged 11–18 years in Great Britain is rising (from 3.7% in 2013 to 9.3% in 2016) [5]. However, regular (at least monthly) use among young people is low, and increases in regular use are mainly restricted to current smokers (from 20.2% in 2015 to 27.2% in 2016), with regular use by never smokers remaining rare (.6% in 2015 to .4% in 2016) [5].

Cross-sectional studies have found that young people who use e-cigarettes are more likely to smoke [6,7], intend to smoke [8,9], and be susceptible to smoking [10] than those who do not. On the other hand, among young people in Great Britain, ex- and current smokers are more likely to intend to use e-cigarettes than never smokers [11]. It is therefore difficult to determine whether there is any causality, and it is likely that there is an underlying factor driving both smoking and e-cigarette use.

Several longitudinal studies of U.S. youth have found baseline e-cigarette use is associated with smoking initiation [12–17], past six-month smoking [18], and past-month smoking [19] at follow-up. A meta-analysis of these studies has confirmed the strength and consistency of these associations [4], and the association between ever e-cigarette use and smoking initiation has since been replicated in England [20] and Scotland [21].

Although each of the above studies exploring the association between e-cigarette use and smoking control for a variety of factors associated with smoking, there remains the presence of extraneous variables, which may be related to both smoking and e-cigarette use. Furthermore, some researchers propose that certain psychosocial processes lead to vulnerability to any drug use [22,23]. One study [18] explored whether the association between smoking and e-cigarettes works both ways, and found that not only was use of e-cigarettes at baseline associated with past six-month smoking at follow-up, but also smoking at baseline was associated with past six-month e-cigarette use at follow-up. Furthermore, among young people in Argentina, current smoking was associated with e-cigarette initiation one and a half years later [24].

Despite the above research, the relative contributions of e-cigarette use to smoking initiation, and smoking to e-cigarette initiation, have not been formally assessed. All studies in this field with the exception of Wills and colleagues [15] have relied on standard regression models [12–14,16–21,24], which allow only limited conclusions to be drawn regarding the pathways between these products. Therefore, in this study, we have included causal mediation analyses [25] to investigate the causal influence of e-cigarette use on smoking initiation, and smoking on e-cigarette initiation.

This study is the first to our knowledge to explore the longitudinal association between (1) ever e-cigarette use and smoking initiation (ever smoking at follow-up) among baseline never smokers, and (2) ever smoking and e-cigarette initiation (ever e-cigarette use at follow-up) among baseline never e-cigarette users, among young people in Great Britain. We additionally explore whether escalation of each product between baseline and follow-up is associated with initiation of the alternative product, and employ causal mediation analyses for the identification of mediating factors [25] to investigate specific pathways between the two products.

Methods

Design

This study used data from the 2016 Action on Smoking and Health Great Britain Youth longitudinal survey. A non-probability quota sampling approach was adopted using Ipsos MORI's online panels to recruit respondents aged 11–18 years. Quotas were set in respect of age, gender, and Government Office Region (GOR) using data from Eurostat 2012 to ensure sample representativeness. Respondents were invited by email to participate in an online survey about smoking between April 6 and 20 with follow-up between August 5 and October 7, 2016. Up to eight email reminders were sent to maximize follow-up rates. Each wave took approximately 10 minutes to complete, and financial incentives were provided via a prize draw. Informed consent to take part in the surveys was provided either by the parents of those aged 11–15 years or by those individuals aged 16–18 years. Ethical approval for the analyses in this paper was not required as this study used secondary pre-existing data.

Ipsos MORI's online panel applicants consist of volunteers from the general public. These panel applicants are validated by a means of sophisticated vetting procedures using a variety of recruitment channels. Shortly after joining, panelists' survey-taking behavior is tested, with those most likely to make intentional or unintentional errors on future surveys deactivated. Subsequently, panelists' behavior is monitored and tracked across all surveys for quality reasons.

Sample

The baseline survey was completed by 2,916 respondents aged 11–18 years, of whom 1,469 (50%) successfully completed the follow-up survey. We excluded 317 respondents (22%) who had never heard of e-cigarettes and selected "don't know" or "prefer not to say" to some questions (see full breakdown in Figure 1). This left a final study sample of 1,152, of whom 923 (80%) were baseline never smokers and 1,020 (89%) were baseline never e-cigarette users (Figure 1).

Measures

Smoking and e-cigarette status. At baseline, respondents were classified as never smokers (never smoked, not even a puff) or ever smokers; at follow-up, respondents were classified as never smokers or initiated smoking (never smokers at baseline but ever

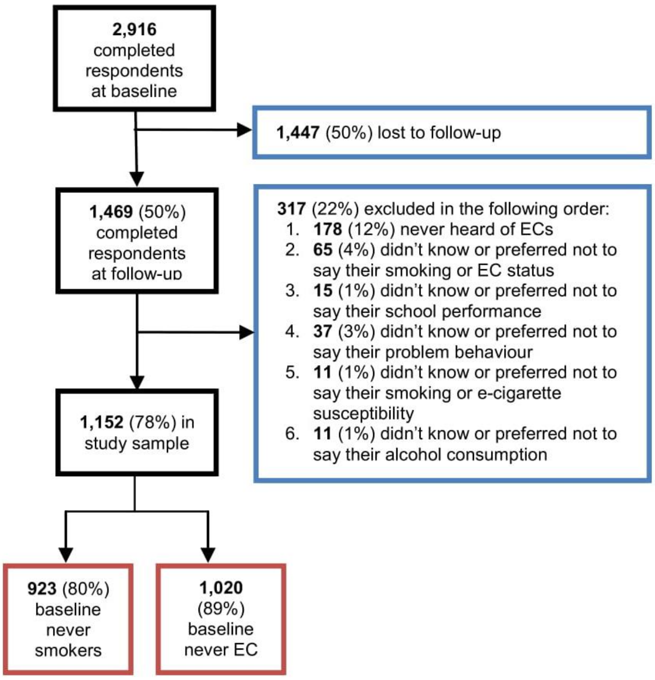

Figure 1. Flow diagram illustrating the respondent selection process. EC = electronic cigarette.

smokers at follow-up). At follow-up, respondents were further classified as having escalated smoking (increased their smoking between baseline and follow-up, e.g., escalating from never smoking to trying smoking, from smoking sometimes to smoking between one and six cigarettes a week) or not escalated smoking. Respondents were classified using the same procedure for e-cigarette use. Respondents who had never heard of e-cigarettes (n = 178), and those who responded with "Prefer not to say" or "Don't know" to the smoking or e-cigarette question at either baseline or follow-up (n = 65) were excluded from all analyses. Full item wording and response options are available in Table A1 (Supplementary Data).

Covariates (assessed at baseline only). Age (11–13, 14–15, 16–18), gender (male, female), school performance (1–4, below average to excellent), problem behavior (2–8, 8 = greater problem behavior), monthly alcohol use (yes, no), smoking susceptibility (susceptible, not susceptible) [26], e-cigarette susceptibility (susceptible, not susceptible—to mirror smoking susceptibility [26]), some friends smoke (yes, no, not applicable/don't know), some friends use e-cigarettes (yes, no, not applicable/don't know), at least one parent smokes (yes, no), at least one parent uses e-cigarettes (yes, no), sibling(s) smoke (yes, no, not applicable/don't know), sibling(s) use e-cigarettes (yes, no, not applicable/don't know), public approve of smoking (yes, no), and public approve of e-cigarettes (yes, no) [27]. For school performance, problem behavior, monthly alcohol use, and smoking and e-cigarette susceptibility, "Don't know" and "Prefer not to say" responses were excluded from all analyses. Covariates specific to smoking were selected based on the previous literature [12,15,18,26–28] and friend, parental, and sibling e-cigarette use and public approval of e-cigarettes were also included to mirror the similar smoking measures and to explore potential shared risk factors for each product. Full item wording, response options, and further details on coding for all covariates are available in Table A1 (Supplementary Data).

Statistical analysis

We used unadjusted logistic regressions to compare respondents lost to follow-up with those retained and included in the study sample. We then used chi-square tests to compare smoking and e-cigarette status at baseline and follow-up. We used unadjusted and adjusted logistic regressions to explore the associations between (1) ever e-cigarette use at baseline and e-cigarette escalation between baseline and follow-up with smoking initiation at follow-up among baseline never smokers (n = 923), and (2) ever smoking at baseline and smoking escalation between baseline and follow-up with e-cigarette initiation at follow-up among baseline never e-cigarette users (n = 1,020). In adjusted models, we adjusted for all covariates described in the Measures section.

To decompose the causal effect of e-cigarette use on smoking initiation, and smoking on e-cigarette initiation, we used causal mediation analyses using the parametric g-computation procedure [25]. Mediation analyses go beyond standard regression models, which can estimate the associations between use of both products, by disentangling different pathways that could explain the effect of an exposure on an outcome. Furthermore, when a potential mediator is treated as confounder in standard regression models, spurious associations may arise. The most commonly used mediation analysis in epidemiology is based on the Baron and Kenny approach [29], in which the total effect of an exposure on an outcome, the effect of the exposure explained by a given set of mediators (indirect effect), and the effect of the exposure unexplained by those same mediators (direct effect) can be defined. This approach has four main problems as it (1) assumes no unmeasured confounding between mediator and outcome, (2) assumes no interactions between exposure and mediator on outcome, (3) does not extend to nonlinear models, and (4) assumes correctly specified models.

Causal mediation analysis has arisen from the causal inference literature [30] and addressed problems of the Baron and Kenny approach [29] under the potential outcomes framework, first by defining (using potential outcomes) precisely what is meant by direct and indirect effects, second by giving clear assumptions under which they can be identified, and third by generalizing the statistical methods available for carrying out such analyses to allow for nonlinearities, interactions, discrete outcomes, and semiparametric estimation [31]. We therefore use the parametric g-computation procedure under this framework as it can quantify reliable direct and indirect causal effects for binary variables, and produces narrow confidence intervals to allow for stronger conclusions to be made regarding observed associations [25,32]. The g-computation procedure is discussed in detail elsewhere [25,31,32], but primarily relies on the parametric modeling assumptions shared with logistic regression and, to infer causality, assumes no unmeasured confounding. It has been applied to survey data previously [33].

To assess the causal influence of e-cigarette use on smoking initiation, we specified a direct effect from ever e-cigarette use at baseline to smoking initiation at follow-up and an indirect effect acting through e-cigarette escalation between baseline and follow-up (mediator). We used the same approach to assess the causal influence of ever smoking on e-cigarette initiation at follow-up with smoking escalation between baseline and follow-up acting as a mediator. The causal diagrams for each model are shown in Figure 2. In the causal mediation analyses, all covariates described in the Measures section were specified as baseline confounders. The g-computation estimates were converted to odds ratios via exponentiation.

For attrition analysis and causal mediation analyses, we used unweighted data; for all other analyses, we used weighted data unless otherwise specified. Data were weighted according to age, gender, and GOR using data from the Eurostat 2012, and adjusted for attrition on age, gender, GOR, ever smoking, and ever e-cigarette use. Missing data were excluded listwise from all analyses (see Figure 1).

Results

Table 1 shows the characteristics of the study sample at baseline (n = 1,152) compared with respondents lost to follow-up and who would have otherwise been excluded (because of not having heard of e-cigarettes or selecting "don't know" or "prefer not to say" on key variables and covariates) (n = 1,225). Respondents were more likely to be lost to follow-up if they had ever smoked and ever used an e-cigarette, and also differed on all covariates included in the study except smoking susceptibility and having at least one parent who uses e-cigarettes.

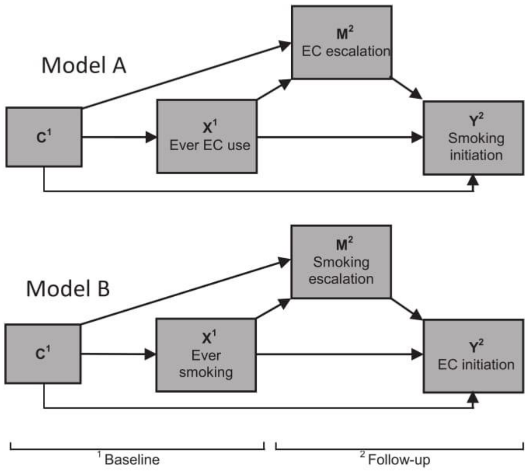

Figure 2. Conceptual causal diagrams for mediation and confounding. C = Covariate(s); X = Exposure; M = Mediator; Y = Outcome, EC = E-cigarette. Model A specifies baseline ever e-cigarette use as the exposure, e-cigarette escalation at follow-up as the mediator, and smoking initiation at follow-up as the outcome. Model B specifies baseline ever smoking as the exposure, smoking escalation at follow-up as the mediator, and e-cigarette initiation at follow-up as the outcome.

At baseline, 229 respondents (19.9%) had ever smoked (Table 1), and this increased to 301 (26.0%) at follow-up ($\chi^2 = 834.32$, $p < .001$). Of the 229 baseline ever smokers, 111 (48.5%) were also ever e-cigarette users; of the 923 baseline never smokers, 21 (2.3%) were ever e-cigarette users. At baseline, 132 respondents (11.5%) had ever used an e-cigarette (Table 1), increasing to 204 (17.6%) at follow-up ($\chi^2 = 761.74$, $p < .001$). Of the 132 baseline ever e-cigarette users, 111 (84.0%) were also ever smokers; of the 1,020 baseline never e-cigarette users, 118 (11.6%) were ever smokers. At baseline, only 56 (4.9%) respondents smoked monthly or more and 24 (2.1%) used an e-cigarette monthly or more.

Compared with baseline never e-cigarette users, ever e-cigarette users were more likely to initiate smoking at follow-up (Table 2). Furthermore, respondents who escalated e-cigarette use between baseline and follow-up were also more likely to initiate smoking at follow-up compared with those who did not (Table 2).

Compared with baseline never smokers, ever smokers were more likely to initiate e-cigarette use at follow-up (Table 3). Furthermore, respondents who escalated smoking between baseline and follow-up were also more likely to initiate e-cigarette use at follow-up compared with those who did not (Table 3).

Having some friends who use an e-cigarette reduced the likelihood of smoking initiation (Table 2) but increased the likelihood of e-cigarette initiation (Table 3). Being older, susceptible to smoking, and having at least one parent who smokes were associated with an increased likelihood of smoking initiation (Table 2). Monthly alcohol use and no perceived public approval of smoking were associated with an increased likelihood of e-cigarette initiation (Table 3).

Table 1
Respondent characteristics of the study sample at baseline (n = 1,152) and comparison with those lost to follow-up who would have otherwise been excluded (n = 1,225)

	Study sample (n = 1,152)	Lost to follow-up and excluded (n = 1,225)	OR (95% CI)
Ever smoked	229 (19.88)	382 (31.18)	**.55 (.45–.66)**
Ever used e-cigarettes	132 (11.46)	297 (24.24)	**.40 (.32–.51)**
Female	620 (53.82)	564 (46.04)	**1.37 (1.16–1.61)**
Age			
11–13	438 (38.02)	375 (30.61)	
14–15	338 (29.34)	263 (21.47)	1.10 (.89–1.36)
16–18	376 (32.64)	587 (47.92)	**.55 (.45–.66)**
School performance (1–4, 4 = excellent), mean (SD)	3.05 (.8)	2.97 (.8)	**1.11 (1.01–1.22)**
Problem behavior (2–8, 8 = high), mean (SD)	2.93 (1.2)	3.30 (1.4)	**.80 (.75–.86)**
Monthly alcohol use	269 (23.35)	407 (33.22)	**.61 (.51–.73)**
Susceptible to smoking	146 (12.67)	151 (12.33)	.86 (.67–1.11)
Susceptible to using e-cigarettes	264 (22.92)	330 (26.94)	**.63 (.52–.77)**
Some friends smoke			
No	371 (32.2)	279 (22.78)	
Yes	727 (63.11)	894 (72.98)	**.61 (.51–.73)**
DK/NA	54 (4.69)	52 (4.24)	.78 (.52–1.18)
Some friends use e-cigarettes			
No	684 (59.38)	526 (42.94)	
Yes	399 (34.64)	620 (50.61)	**.49 (.42–.59)**
DK/NA	69 (5.99)	79 (6.45)	**.67 (.48–.95)**
At least one parent smokes	343 (29.77)	413 (33.71)	**.83 (.70–.99)**
At least one parent uses e-cigarettes	182 (15.8)	221 (18.04)	.85 (.69–1.06)
Sibling(s) smokes			
No	918 (79.69)	935 (76.33)	
Yes	127 (11.02)	191 (15.59)	**.68 (.53–.86)**
NA/DK	107 (9.29)	99 (8.08)	1.10 (.83–1.47)
Sibling(s) use e-cigarettes			
No	992 (86.11)	1016 (82.94)	
Yes	54 (4.69)	119 (9.71)	**.46 (.33–.65)**
NA/DK	106 (9.20)	90 (7.35)	1.21 (.90–1.62)
Public approve of smoking	33 (2.86)	62 (5.06)	**.55 (.36–.85)**
Public approve of e-cigarettes	43 (3.73)	90 (7.35)	**.49 (.34–.71)**

All data are unweighted. Significant associations ($p < .05$) are highlighted in **bold.**
N (%) of the samples are reported unless otherwise stated.

In the causal mediation analysis (Figure 2, model A), baseline ever e-cigarette use had a direct causal effect on smoking initiation at follow-up (odds ratio [OR] = 1.34, 95% confidence interval [CI] = 1.05–1.72, $p = .018$), and there was a significant total causal effect of the model (OR = 1.35, 95% CI = 1.04–1.74, $p = .022$). However, there was no indirect effect of baseline ever e-cigarette use on smoking initiation at follow-up mediated by e-cigarette escalation between baseline and follow-up (OR = 1.00, 95% CI = .91–1.11, $p = .983$).

In the causal mediation analysis (Figure 2, model B), baseline ever smoking had a direct causal effect on e-cigarette initiation at follow-up (OR = 1.08, 95% CI = 1.01–1.17, $p = .034$), and there was a significant total causal effect of the model (OR = 1.11, 95% CI = 1.03–1.20, $p = .006$). However, there was no indirect effect of baseline ever smoking on e-cigarette initiation at follow-up mediated by smoking escalation between baseline and follow-up (OR = 1.03, 95% CI = .99–1.06, $p = .106$).

Discussion

This study was the first to explore the longitudinal association between e-cigarette use and smoking initiation, and smoking and e-cigarette initiation among young people in Great Britain, and to assess the relative contribution of these associations using a causal inference approach. In the logistic regression analyses, we found evidence for a prospective association between ever e-cigarette use and smoking initiation, and between ever smoking and e-cigarette initiation. We also found that escalation of each product (e-cigarettes and smoking) between baseline and follow-up was associated with initiation of the alternative product. The causal mediation analyses confirmed the direct effect of baseline ever e-cigarette use on smoking initiation, and baseline ever smoking on e-cigarette initiation, but found that e-cigarette and smoking escalation, respectively, did not mediate these effects.

This study provides insight into the impact of e-cigarette use on smoking and vice versa in young people; however, the findings must be considered in the light of some limitations. Attrition was high and respondents lost to follow-up differed substantially from those retained, potentially reducing generalizability to ever smokers, ever e-cigarette users, males, older respondents, and those with poorer school performance and greater problem behavior.

Although this study controlled for a variety of factors previously associated with smoking and e-cigarette use to enhance approximation of the models, there are still several factors that were not included that may contribute to the observed association between these products [28]. Examples may include curiosity, sensation seeking, liking, or disliking the effects of smoking/e-cigarettes, expectancies of smoking/e-cigarettes, mental ill health, and use of other drugs [28]. Furthermore, there are likely to be contributing factors that cannot be easily measured in surveys such as biological or genetic vulnerabilities, although drug use and parent's smoking and e-cigarette use may act as an indicator of these. Larger sample sizes are required to enable this substantial number of covariates to be assessed and meaningfully interpreted.

Table 2
Associations between smoking initiation at follow-up and e-cigarette use and all covariates, among baseline never smokers (n = 923)

	n (% initiated smoking)	Unadjusted		Adjusted model 1[a]		Adjusted model 2[b]	
		OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Baseline EC use							
Never	902 (8.2)	1.00		1.00		1.00	
Ever	21 (52.6)	**12.41 (4.53–33.99)**	**<.001**	**10.57 (3.33–33.50)**	**<.001**	**11.89 (3.56–39.72)**	**<.001**
Follow-up EC use							
No escalation	882 (8.1)	1.00		–	–	1.00	
Escalation	41 (41.0)	**7.94 (3.75–16.82)**	**<.001**	–	–	**7.89 (3.06–20.38)**	**<.001**
Age							
11–13	397 (4.4)	1.00		1.00		1.00	
14–15	270 (6.3)	1.45 (.71–2.97)	.312	1.22 (.54–2.73)	.636	1.35 (.58–3.15)	.485
16–18	256 (16.1)	**4.12 (2.19–7.76)**	**<.001**	**4.02 (1.72–9.40)**	**.001**	**4.98 (2.07–12.00)**	**<.001**
Gender							
Male	428 (10.8)	1.00		1.00		1.00	
Female	495 (8.5)	.77 (.46–1.30)	.331	.90 (.48–1.68)	.738	.91 (.47–1.76)	.786
School perf. (1–4, 4 = excellent)[c]	2.93 (.9)	.76 (.53–1.08)	.124	.91 (.64–1.29)	.596	.90 (.64–1.29)	.579
Problem beh. (2–8, 8 = high)[c]	3.05 (1.3)	**1.31 (1.03–1.66)**	**.028**	1.06 (.82–1.37)	.659	1.05 (.81–1.36)	.705
Monthly alcohol use							
No	790 (7.8)	1.00		1.00		1.00	
Yes	133 (18.1)	**2.61 (1.42–4.80)**	**.002**	1.64 (.82–3.30)	.165	1.32 (.61–2.86)	.480
Smoking susceptibility							
No	777 (7.9)	1.00		1.00		1.00	
Yes	146 (19.8)	**2.88 (1.57–5.29)**	**.001**	**2.38 (1.17–4.84)**	**.016**	**2.61 (1.23–5.52)**	**.012**
Some friends smoke							
No	355 (5.4)	1.00		1.00		1.00	
Yes	515 (12.9)	**2.60 (1.34–5.07)**	**.005**	1.48 (.66–3.34)	.341	1.28 (.57–2.87)	.555
NA/DK	53 (1.9)	.35 (.04–2.76)	.317	.30 (.04–2.43)	.258	.29 (.04–2.36)	.246
Some friends use EC							
No	598 (8.6)	1.00		1.00		1.00	
Yes	264 (11.0)	1.32 (.73–2.40)	.358	**.47 (.24–.93)**	**.029**	**.35 (.17–.75)**	**.007**
NA/DK	61 (15.1)	1.90 (.73–4.94)	.188	1.99 (.78–5.10)	.150	1.80 (.72–4.51)	.212
At least one parent smokes							
No	676 (6.8)	1.00		1.00		1.00	
Yes	247 (18.0)	**2.99 (1.72–5.20)**	**<.001**	**2.97 (1.62–5.44)**	**<.001**	**2.65 (1.37–5.12)**	**.004**
At least one parent uses EC							
No	802 (8.4)	1.00		1.00		1.00	
Yes	121 (18.8)	**2.54 (1.35–4.76)**	**.004**	1.47 (.70–3.07)	.304	1.33 (.65–2.73)	.437
Sibling(s) smoke							
No	761 (8.5)	1.00		1.00		1.00	
Yes	71 (20.8)	**2.83 (1.23–6.51)**	**.015**	.75 (.30–1.84)	.527	.84 (.33–2.16)	.723
NA/DK	91 (10.4)	1.25 (.56–2.82)	.584	1.65 (.56–4.92)	.365	1.94 (.66–5.69)	.226
Sibling(s) use EC							
No	810 (9.3)	1.00		1.00		1.00	
Yes	28 (24.3)	**3.13 (1.09–9.01)**	**.034**	2.16 (.54–8.58)	.274	1.59 (.35–7.27)	.551
NA/DK	85 (9.3)	1.00 (.41–2.41)	.998	.72 (.20–2.53)	.604	.67 (.19–2.41)	.543
Public approve of smoking							
No	903 (9.5)	1.00		1.00		1.00	
Yes	20 (20.5)	2.45 (.60–9.96)	.209	1.33 (.34–5.16)	.676	1.87 (.48–7.19)	.365
Public approve of ECs							
No	907 (9.7)	1.00		1.00		1.00	
Yes	16 (9.8)	1.00 (.20–4.99)	.997	.39 (.07–2.05)	.263	.40 (.08–1.92)	.252

Adjusted model 1 constant OR = .02 (95% CI = .00–.11) $p < .001$. Adjusted model 2 constant OR = .02 (95% CI = .00–.10), $p < .001$. N and % illustrate the number and percentage of individuals who initiated smoking at follow-up. All n use unweighted data, % and analyses use weighted data.
Significant associations ($p < .05$) are highlighted in **bold.**
beh. = behavior; EC = e-cigarette; perf. = performance.
[a] Adjusted model 1 is adjusted for all variables listed except follow-up EC use.
[b] Adjusted model 2 is adjusted for all variables listed.
[c] Mean(SD) reported, mean (SD) for never smoked at follow-up: school performance = 3.12 (.8), problem behavior = 2.71 (1.0).

Another important limitation is that this study uses the outcomes smoking initiation and e-cigarette initiation defined as progressing from never to ever use of each product. This is similar to some previous studies [12–16,21,24], yet the use of such broad measures has been criticized for providing limited evidence of progression to any significant smoking behavior [28,34]. However, because of low prevalence rates of monthly or more smoking (5%) and e-cigarette use (2%) in this study's sample, options for refining the measures were limited. Therefore, although the present study found an association between ever smoking and ever e-cigarette use, these cannot be generalized to current or regular use, and it cannot be determined whether e-cigarette experimentation leads to regular smoking. Such questions are critical in this area of research. Surveys with multiple waves across several years with larger sample sizes are needed to enable higher numbers of ever and current smokers and e-cigarette users, and further dissect the association between the two products.

Table 3
Associations between e-cigarette initiation at follow-up and smoking and all covariates, among baseline never e-cigarette users (n = 1,020)

	n (% initiated EC use)	Unadjusted		Adjusted model 1[a]		Adjusted model 2[b]	
		OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Baseline smoking							
Never	902 (4.1)	1.00		1.00		1.00	
Ever	118 (32.4)	**9.48 (5.36–16.76)**	**<.001**	**3.69 (1.88–7.23)**	**<.001**	**3.54 (1.68–7.45)**	**.001**
Follow-up smoking							
No escalation	932 (5.9)	1.00		—	—	1.00	
Escalation	88 (33.5)	**8.00 (4.36–14.69)**	**<.001**	—	—	**5.79 (2.55–13.15)**	**<.001**
Age							
11–13	413 (5.6)	1.00		1.00		1.00	
14–15	294 (6.1)	1.11 (.54–2.27)	.779	.65 (.29–1.43)	.285	.57 (.25–1.27)	.168
16–18	313 (12.5)	**2.41 (1.29–4.51)**	**.006**	.69 (.31–1.55)	.374	.48 (.19–1.18)	.109
Gender							
Male	468 (10.2)	1.00		1.00		1.00	
Female	552 (7.3)	.70 (.41–1.17)	.171	.77 (.41–1.43)	.404	.73 (.39–1.37)	.331
School perf. (1–4, 4 = excellent)[c]	2.67 (.9)	**.57 (.42–.78)**	**<.001**	.81 (.58–1.14)	.226	.79 (.55–1.12)	.183
Problem beh. (2–8, 8 = high)[c]	3.51 (1.4)	**1.62 (1.30–2.03)**	**<.001**	1.20 (.93–1.53)	.154	1.13 (.87–1.47)	.352
Monthly alcohol use							
No	824 (5.0)	1.00		1.00		1.00	
Yes	196 (20.6)	**4.93 (2.87–8.47)**	**<.001**	**2.66 (1.27–5.61)**	**.010**	**2.40 (1.08–5.33)**	**.032**
EC susceptibility							
No	756 (5.1)	1.00		1.00		1.00	
Yes	264 (18.9)	**4.39 (2.51–7.67)**	**<.001**	1.53 (.83–2.83)	.173	1.67 (.86–3.27)	.131
Some friends smoke							
No	363 (2.4)	1.00		1.00		1.00	
Yes	603 (12.3)	**5.58 (2.44–12.73)**	**<.001**	1.97 (.86–4.50)	.107	1.95 (.87–4.36)	.105
NA/DK	54 (5.5)	2.34 (.56–9.84)	.247	3.24 (.60–17.36)	.170	4.31 (.88–21.13)	.071
Some friends use EC							
No	660 (5.7)	1.00		1.00		1.00	
Yes	293 (15.9)	**3.14 (1.81–5.45)**	**<.001**	**2.69 (1.48–4.87)**	**.001**	**3.03 (1.63–5.64)**	**<.001**
NA/DK	67 (6.4)	1.15 (.31–4.19)	.835	1.10 (.20–6.14)	.915	.78 (.14–4.54)	.785
At least one parent smokes							
No	733 (6.6)	1.00		1.00		1.00	
Yes	287 (14.9)	**2.47 (1.45–4.23)**	**.001**	1.88 (.91–3.91)	.090	1.45 (.61–3.46)	.405
At least one parent uses EC							
No	884 (7.6)	1.00		1.00		1.00	
Yes	136 (17.3)	**2.54 (1.38–4.67)**	**.003**	2.34 (1.00–5.47)	.051	2.1 (.87–5.07)	.097
Sibling(s) smoke							
No	830 (7.4)	1.00		1.00		1.00	
Yes	94 (24.0)	**3.94 (2.00–7.75)**	**<.001**	1.49 (.66–3.36)	.332	1.64 (.69–3.91)	.266
NA/DK	96 (3.9)	.51 (.16–1.61)	.251	.36 (.06–2.11)	.258	.27 (.04–1.93)	.193
Sibling(s) use EC							
No	899 (8.3)	1.00		1.00		1.00	
Yes	31 (29.9)	**4.69 (1.50–14.66)**	**.008**	1.46 (.39–5.43)	.576	.92 (.28–3.09)	.895
NA/DK	90 (5.6)	.66 (.23–1.83)	.420	1.03 (.21–5.11)	.969	1.10 (.19–6.27)	.917
Public approve of smoking							
No	1000 (9.0)	1.00		1.00		1.00	
Yes	20 (2.8)	.29 (.04–2.22)	.233	**.09 (.01–.88)**	**.038**	.15 (.02–1.22)	.076
Public approve of ECs							
No	995 (8.5)	1.00		1.00		1.00	
Yes	25 (20.9)	2.84 (.95–8.50)	.061	.99 (.31–3.15)	.987	1.32 (.34–5.15)	.689

Adjusted model 1 constant OR = .02 (95% CI = .00–.07) $p < .001$. Adjusted model 2 constant OR = .02 (95% CI = .00–.10), $p < .001$. N and % illustrate the number and percentage of individuals who initiated EC use at follow-up. All n use unweighted data, % and analyses use weighted data.
Significant associations ($p < .05$) are highlighted in **bold.**
beh. = behavior; EC = e-cigarette; perf. = performance.
[a] Adjusted model 1 is adjusted for all variables listed except follow-up smoking.
[b] Adjusted model 2 is adjusted for all variables listed.
[c] Mean (SD) reported, mean (SD) for never used EC at follow-up: school performance = 3.08 (.8), problem behavior = 2.77 (1.0).

Despite the above limitations, this study has several strengths. It was the first to explicitly explore the association not only between e-cigarette use at baseline and smoking initiation at follow-up but additionally smoking at baseline and e-cigarette initiation at follow-up. Moreover, a novel statistical approach (causal mediation analysis [25]) was used to explore whether the association between baseline ever e-cigarette use and smoking initiation at follow-up was mediated by escalation of e-cigarette use between survey waves; the same procedure was also used to explore further the association between smoking and e-cigarette initiation. To our knowledge this has not been done previously. Finally, the sample was drawn from the general population in Great Britain using a quota sampling approach to enhance representativeness.

The rate of ever smoking in this study was 19.9% at baseline, which is lower than other findings in Great Britain in 2016 [5], but could be because of those lost at follow-up being more likely to smoke. The rate of ever e-cigarette use (11.5% at baseline) and findings that ever e-cigarette use was largely confined to those who had ever smoked, with a low proportion of never smokers having ever used e-cigarettes, was consistent with other findings in Great Britain [5,35]. Furthermore, only 4% of never smokers initiated e-cigarette use (vs. 32% of ever smokers). This suggests that e-cigarettes are attracting few who have never smoked. Furthermore, monthly or more smoking and e-cigarette use was low, at 5% and 2%, respectively.

In the logistic regression analyses, e-cigarette escalation between baseline and follow-up was associated with smoking initiation, even when controlling for ever e-cigarette use; likewise, smoking escalation was associated with e-cigarette initiation when controlling for ever smoking. This represents a novel contribution to the literature, and further suggests the need for multi-wave surveys to explore dynamic changes in use of both products over time. Despite this, the causal mediation analyses, which as discussed allow for stronger conclusions to be made regarding observed observations, suggest that it is primarily ever use of that product that contributes to initiation of the alternative product.

Our findings are consistent with previous studies that found a prospective association between e-cigarette use at baseline and smoking at follow-up [4,12–21], and also with those who found a prospective association between smoking at baseline and e-cigarette use at follow-up [18,24]. There are several possible reasons for the strong and reliable association between e-cigarettes and smoking in young people [18,28,36]. One interpretation is that e-cigarettes act as a "gateway" to smoking [3,37]; however, this has been contested [28,36], and our findings suggest that the association between e-cigarette initiation and smoking initiation may work both ways. Certain psychological processes ("common liabilities") may lead to vulnerability of any drug use [22,23]. Specifically, young people who exhibit curiosity, rebelliousness, and sensation-seeking may be more likely to experiment with both smoking and e-cigarettes. Future research should explore potential common liabilities pertaining to experimentation of both products, some of which were included in this study and others are proposed above.

Despite potential common liabilities and our findings that e-cigarette use is associated with smoking and vice versa, there are several important differences to consider between these products and the contexts in which they may be used. Among young people, e-cigarettes, compared with conventional cigarettes, have been described as more accessible and convenient [38,39], have a greater capacity for continual novelty in terms of flavors and devices [39], and are perceived as less harmful in the UK [5,39]. On the contrary, smoking is highly stigmatized in some societal groups [40]. Indeed, some have reported that e-cigarettes appeal to those who do not want to smoke but want to try the experience of "smoking" [38,39].

Interestingly, friend's e-cigarette use increased the likelihood of e-cigarette initiation but reduced the likelihood of smoking initiation in adjusted models. This first association is unsurprising given the important role of peer influence on behavior. However, the protective effect of friend's e-cigarette use on smoking initiation warrants further investigation.

In conclusion, this study provides further support for the association between ever e-cigarette use and smoking initiation, and additionally finds that ever smoking is associated with e-cigarette initiation, among young people. Better understanding of these associations will aid policy makers with their efforts to develop an appropriate regulatory framework for both tobacco products and e-cigarettes.

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Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jadohealth.2017.11.301.

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4.3. Discussion in relation to this thesis

In my publication above I provided the first assessment of the longitudinal associations between (i) vaping and subsequent smoking initiation and (ii) smoking and subsequent vaping initiation among British youth [1]. Consistent with previous research [146-157], I found that youth who vape had greater odds of subsequently initiating smoking. Also consistent with previous research [154, 159], I found that youth who smoke had greater odds of subsequently initiating vaping. I confirmed these results using causal mediation analyses. Together, my findings suggest that there may be a reciprocal relationship between vaping and smoking initiation.

In my publication above [1], I also assessed the longitudinal associations between (iii) smoking and vaping norms and smoking initiation, and (iv) smoking and vaping norms and vaping initiation. However, I did not discuss these findings in detail in my publication [1] because of limited word count. The focus of this discussion is therefore on the social norms findings [2].

I found that having at least one parent who smokes increased the odds of smoking initiation, having friends who vape reduced the odds of smoking initiation but increased the odds of vaping initiation, and perceiving public approval of smoking reduced the odds of vaping initiation [1]. I found little evidence to support any other associations between social norms and smoking or vaping initiation [1].

My publication [1] was included in my systematic review and meta-analysis in Chapter 2. Consistent with several other studies in the systematic review and meta-analysis, and with previous reviews [96, 99], I found that parent smoking was positively associated with smoking initiation [1]. However, inconsistent with several other studies (Chapter 2 and [96, 99]), I did not find associations between sibling and friend smoking and youth smoking initiation when adjusting for covariates [1]. Despite this, sibling and friend smoking were associated with youth smoking initiation in unadjusted analyses, suggesting that some covariates in the adjusted model may have been acting as confounders [1]. In particular, because my study [1] measured parent, friend, and sibling use of both tobacco cigarettes and e-cigarettes, and it is possible that the use of one product confounds use of the other. For example, friends who vape may also smoke. Future studies should explore the effect of having parents, siblings, and friends who concurrently smoke and vape, who use either product exclusively, or who have switched from smoking to vaping.

I also found little evidence that parent and sibling vaping were associated with vaping initiation when adjusting for covariates [1]. Again, this could be explained by confounding. However, consistent with previous cross-sectional research, I found that having friends who vape increased the odds of vaping initiation [1, 15, 136, 137, 166]. The longitudinal nature of my study provides more information about the direction of these associations and suggests that the vaping behaviour of friends can precede and predict vaping initiation. This is a novel and important contribution to the literature.

Prior to my publication [1], only one study had explored the longitudinal associations between societal-level injunctive norms and youth smoking initiation [104] (see Chapter 2). This previous study found that perceived community disapproval of smoking predicted smoking initiation in unadjusted but not adjusted analyses [104]. However, my study [1] found little evidence of an association between public approval of smoking and youth smoking initiation in either adjusted or unadjusted analyses. Similarly, in my study [1] I did not find an association between perceiving that the public approve of vaping and vaping initiation . It is possible that societal-level injunctive norms may have less of an influence on youth smoking/vaping initiation than some might suppose. However, only 20 of 923 never smokers perceived public approval of smoking, while 25 of 1,020 never vapers perceived public approval of vaping [1]. The lack of associations could therefore be because of low power.

I found strong evidence that having friends who vape reduced the odds of smoking initiation almost three-fold, despite increasing the odds of vaping initiation [1]. This finding suggests that having friendship groups consisting of vapers may protect against youth smoking, which would appear contrary to claims that vaping is renormalising smoking [35, 48, 50-56]. I also found some evidence of a negative association between perceived public approval of smoking and vaping initiation [1]. Again, this suggests possible inverse associations between norms towards one product and use of the other. Interestingly, both associations only emerged once adjusting for covariates [1], suggesting negative confounding or the presence of interactions. Because of low sample size I did not explore interactions in my publication [1]. Future studies should explore the role of friend vaping on smoking initiation, and perceived public approval of smoking and vaping initiation, in greater depth with larger sample sizes.

4.3.1. Conclusion

My findings from this Chapter (Chapter 4) suggest that there may be a reciprocal relationship between vaping initiation and smoking initiation among British youth [1]. Consistent with previous research [146-157, 159], I found a positive association between trying vaping and initiating smoking and also between trying smoking and initiating vaping [1]. I also found that very few never smokers had tried vaping [1], counter to concerns that vaping is attracting non-smoking individuals into nicotine use [35, 48-51]. I found negative associations between friend vaping and smoking initiation, and perceiving public approval of smoking and vaping initiation, which appear counter to claims that vaping is renormalising smoking [35, 48, 51-56]. However, further longitudinal research is required in this area to understand the mechanisms through which smoking and vaping norms and behaviours are related.

4.4. Impact and dissemination

The ASH Great Britain Longitudinal Youth Survey was implemented with the aim of assessing the longitudinal association between vaping and smoking among British youth. My publication therefore forms part of a larger body of evidence led by ASH, monitoring and evaluating smoking and vaping behaviours among British youth.

My publication above [1] was accompanied by a press release [239] and reported on by the National Health Service (NHS) [240] and Cancer Research UK [241]. It was also picked up by journals [242], newspapers [243-246], and bloggers [247-250]. It has been cited in reports by Public Health England [31, 38] and the

Commonwealth Scientific and Industrial Research Organisation [251], which are used to inform policy in the UK and Australia, respectively. The results were also discussed in parliament by Deborah Arnott and Hazel Cheeseman (co-authors of the publication) during the Science and Technology Committee Meeting in March 2018 [252].

My publication [1] stirred a lively debate among international experts in the field. A US academic wrote a letter in response to my publication [253] to which I was invited to respond [6]. This letter provided an opportunity to elaborate on my findings [6]. I drafted this response and all co-authors commented on and agreed the final text. The letter [253] and my response [6] are provided in Appendix H of this thesis.

As of 24th September 2019, my publication [1] had been cited 34 times. According to Web of Science, it ranks as a "highly cited paper" and is in the top 1% in the academic field of Clinical Medicine. My publication [1] was also included in the Journal of Adolescent Health Year in Review collection highlighting "the most important topics in adolescent and young adult health and medicine of 2018".

I presented my publication [1] as an oral presentation at the Lisbon Addictions 2017 Second European Conference on Addictive Behaviours and Dependencies in Lisbon, Portugal (presentation available online at [8]). I also presented some of the findings as part of a presentation on smoking and vaping norms to the National Drug and Alcohol Research Centre at The University of New South Wales in Sydney, Australia (presentation available online at [10]).

CHAPTER 5

Smoking and Vaping Norms and Harm Perceptions of Vaping and Nicotine Among British Youth

5.1. Preface

Vaping is a less harmful method of nicotine consumption than smoking [20, 27, 31, 37, 39-44]. Some behavioural theories have proposed that social norms play a role in shaping harm perceptions and subsequent behaviour [81, 168].

This Chapter I addressed the following objectives: to assess (i) the prevalence of harm perceptions of (a) vaping and (b) nicotine, relative to smoking, and (ii) the correlates of accurate harm perceptions of (a) vaping and (b) nicotine, relative to smoking, using cross-sectional data from a nationally representative sample of British youth age 11-18. Correlates included smoking and vaping norms, smoking and vaping status, and demographic variables.

These objectives relate to *Aim 5* of my thesis: To assess, among youth, the associations between smoking and vaping norms and harm perceptions of vaping and nicotine relative to smoking.

I addressed these objectives, and hence thesis aims, in my second peer-reviewed publication, which is presented in Section 5.2 below [2]:

> *East, K., Brose, L.S., McNeill, A., Cheeseman, H., Arnott, D., & Hitchman, S.C. (2018). Harm perceptions of electronic cigarettes and nicotine: A nationally representative cross-sectional survey of young people in Great Britain. Drug and Alcohol Dependence, 192, 257-263. doi: 10.1016/j.drugalcdep.2018.08.016.*

The focus of my publication [2] was broader than exploring the associations between smoking and vaping norms and harm perceptions of vaping and nicotine. I have therefore discussed the social norms findings in more detail below the publication, in Section 5.3. I have also included a summary of the impact and dissemination of this work, in Section 5.4.

5.1.1. Declaration of roles

I developed this publication [2] in collaboration with Dr Sara C Hitchman, Professor Ann McNeill and Dr Leonie Brose (King's College London), Hazel Cheeseman and Deborah Arnott (Action on Smoking and Health [ASH]), and the survey firm YouGov. HC, DA, and YouGov designed the survey, and YouGov were responsible for sample recruitment and maintenance. SCH, LB, AM, and I provided input on the survey design and measures, particularly the smoking and vaping norms measures which were informed by my previous work [15]. I led the write-up of the publication [2], formulated the research questions, and analysed the data, with input from SCH, LB, and AM. All co-authors reviewed and provided input on drafts of the publication [2].

5.1.2. Selection of social norms measures

In my publication [2] I used data from the 2016 ASH Great Britain Smokefree Youth Survey. I selected three measures of smoking norms and two measures of vaping norms for use in this publication [2]: family smoking, friend smoking, perceived public approval of smoking, family vaping, perceived public approval of vaping (see Table 3.1).

I selected these five social norms measures because they were broadly consistent with those measures included in my publication in Chapter 4 above [1]. They also covered a range of social groups and covered both descriptive and injunctive norms. Perceived societal approval of smoking and vaping were included specifically because my preliminary findings from the systematic review in Chapter 2 suggested that more research on societal-level injunctive norms was needed. The inclusion and wording of all social norms measures in the ASH Great Britain Smokefree Youth Survey were based on discussions with co-authors, ASH, and the survey firm Ipsos MORI. The wording of some social norms measures in this Chapter therefore differed from other Chapters in this thesis.

5.2. Publication

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Full length article

Harm perceptions of electronic cigarettes and nicotine: A nationally representative cross-sectional survey of young people in Great Britain

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ABSTRACT

Background: E-cigarettes often contain nicotine without the most harmful constituents of tobacco smoke.
Aims: This study aims to assess prevalence and correlates of accurately perceiving e-cigarettes as less harmful than cigarettes and that none or a small amount of the harm from smoking comes from nicotine.
Methods: Cross-sectional survey of 2,103 11–18-year-olds in Great Britain in 2016. Prevalence of e-cigarette and nicotine harm perceptions were calculated. Logistic regressions assessed associations between accurate e-cigarette and nicotine harm perceptions and smoking, e-cigarette use, gender, age, region, social grade, family smoking, family e-cigarette use, smoking friends, public approval of smoking, and public approval of e-cigarettes. Associations between accurate e-cigarette and nicotine harm perceptions were also assessed.
Results: Most (63.4%) accurate e-cigarette harm perceptions were higher among those aged 16+ (OR = 1.89 [95%CI = 1.45–2.47]), 14–15 (OR = 1.29 [1.00–1.65]), who tried/used an e-cigarette sometimes (OR = 1.51 [1.03–2.21]), with family e-cigarette use (OR = 2.11 [1.46–3.04]), who perceived public disapproval of smoking (OR = 2.11 [1.18–3.77]) and approval of e-cigarettes (OR = 2.44 [1.73–3.45]), and with accurate nicotine harm perceptions (OR = 2.05 [1.28–3.28]). Accurate nicotine harm perceptions were higher among those aged 16+ (OR = 2.60 [1.62–4.16]), from North England (OR = 1.87 [1.02–3.43]) and Wales/Scotland (OR = 2.61 [1.35–5.03]) vs. London, with family smoking (OR = 1.59 [1.05–2.42]), and with accurate e-cigarette harm perceptions (OR = 2.12 [1.32–3.41]).
Conclusions: Many young people have inaccurate harm perceptions of e-cigarettes and nicotine. Accurate e-cigarette and nicotine harm perceptions were associated with one another. E-cigarette use was associated with accurate e-cigarette but not nicotine harm perceptions; smoking was not associated with either.

1. Introduction

Tobacco smoking is the leading cause of preventable death and disability worldwide (WHO, 2005, 2015). While it is primarily the nicotine in cigarettes that is addictive, most of the health harms of smoking are caused by other constituents of tobacco smoke (Benowitz, 2009). Electronic (e-)cigarettes are battery-powered devices that heat a solution usually containing nicotine, flavourings, propylene glycol and/or vegetable glycerin to produce an inhalable aerosol. As e-cigarettes do not contain tobacco and do not involve combustion, current evidence suggests they are less harmful to both users and others relative to tobacco cigarettes (Czogala et al., 2014; Hajek et al., 2014; Harrell et al., 2014; McAuley et al., 2012; McNeill et al., 2015, 2018; Tobacco Advisory Group of the Royal College of Physicians, 2016).

Over the past decade, there have been many studies assessing the relative harm perceptions of e-cigarettes compared to cigarettes. Depending on the sample, year of data collection, and country, the proportion who accurately perceive that e-cigarettes are less harmful than cigarettes varies between 17% and 82% (Adkison et al., 2013; Ambrose et al., 2014; Amrock et al., 2015; Anand et al., 2015; Brose et al., 2015; Eastwood et al., 2017; Majeed et al., 2017; McNeill et al., 2018; Nayak et al., 2017; Persoskie et al., 2017; Richardson et al., 2014; Thrasher et al., 2016; Yong et al., 2017). In adults from the U.S. (Majeed et al., 2017) and Great Britain (Brose et al., 2015; McNeill

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et al., 2018), it appears that e-cigarettes are being perceived as increasingly harmful over time. Similar patterns are seen among young people in Great Britain, and the proportion who accurately perceive e-cigarettes as less harmful than smoking decreased from 73% in 2013 through 67% in 2014 and 2015 to 62% in 2016 (Eastwood et al., 2017).

Harm perceptions of nicotine are often also incorrect. Compared with tobacco, the harms of sustained nicotine use are negligible, and there is little evidence that nicotine increases cancer risk (Tobacco Advisory Group of the Royal College of Physicians, 2016). However, between 2002 and 2008, only 40–50% of adults in the UK, the US, Australia, and Canada accurately perceived that nicotine is not the chemical that causes most of the cancer in cigarettes (Borland et al., 2011), and this has not changed dramatically since (McNeill et al., 2018). In England in 2009, 40% of adult smokers perceived that long-term use (a year or more) of nicotine replacement therapy (NRT) was not harmful, and of the 31% who perceived that long-term NRT use was harmful, the most commonly reported concerns were addiction, lung cancer, and mouth cancer (Black et al., 2012). Among daily adult smokers from Sweden and Norway, 15% perceived that none or a very small part of the health risks from smoking come from nicotine, while 31% perceived a relatively small part (Wikmans and Ramström, 2010). To-date, there has been little research on the harm perceptions of nicotine among young people, but one study of U.S. Freshmen in 2004 found that 80% accurately reported the nicotine patch to be less harmful than smoking, with corresponding proportions of 76% for nicotine gum and 47% for the nicotine inhaler (Smith et al., 2007). Therefore, the perceived harm of nicotine may depend on the product or the route of administration.

The proportion of inaccurate harm perceptions of e-cigarettes and nicotine is concerning, as it may limit the proportion of smokers willing to try or use a less harmful product which may help them quit. Indeed, adult smokers and ex-smokers who accurately perceive e-cigarettes as less harmful than smoking are more likely to try or currently use an e-cigarette than those who do not hold this perception (Adkison et al., 2013; Brose et al., 2015; Yong et al., 2017). However, this same association has been found among both smoking and non-smoking young people (Ambrose et al., 2014; Amrock et al., 2015; Persoskie et al., 2017; Thrasher et al., 2016), which could be problematic if accurate harm perceptions are encouraging never-smokers to try or use e-cigarettes. On the other hand, young people who perceive that e-cigarettes and smoking are equally as harmful or that e-cigarettes are more harmful may be more likely to transition from e-cigarette use to smoking than those who perceive e-cigarettes as less harmful than smoking. However, there is no research on this to date.

Evidence for associations between harm perceptions of nicotine (or NRT) and using nicotine products is mixed. Borland et al. (2011) found an association between perceiving NRT as less harmful than smoking and using NRT in the past year among smokers and ex-smokers, while Black et al. (2012) found no such association.

In addition to assessing associations between accurate harm perceptions and use of both tobacco cigarettes and e-cigarettes, it is also important to identify potential demographic and social correlates of accurate harm perceptions. It is plausible that exposure to smoking and e-cigarettes by family and friends and perceived approval of these products will influence harm perceptions, particularly among youth, whose smoking and e-cigarette uptake has been found to be influenced by some of these social factors (Chang et al., 2006; East et al., 2018; Forrester et al., 2007; Leonardi-Bee et al., 2011; O'Loughlin et al., 2009, 2014).

To our knowledge, there has been no published data on associations between harm perceptions of e-cigarettes and harm perceptions of nicotine among young people. As e-cigarettes often, although not always, contain nicotine, it should be expected that harm perceptions of both would be correlated.

Given this, this study has the following two aims: (1) to assess the prevalence of harm perceptions of (a) e-cigarettes relative to cigarettes and (b) nicotine in relation to smoking among young people in Great Britain and (2) to assess the correlates of accurate perceptions that (a) e-cigarettes are less harmful than cigarettes and (b) none or a small amount of the harm from smoking comes from nicotine among young people in Great Britain.

2. Methods

2.1. Design and procedure

Data were drawn from the cross-sectional 2016 Action on Smoking and Health (ASH) Smokefree Great Britain Youth survey conducted between 11th March and 10th April 2016. This survey is commissioned annually by ASH and is drawn from an online panel maintained by YouGov PLC. Full details of YouGov PLC's online panel are described in Eastwood et al. (2015). Respondents age 16–18 were sampled directly from YouGov PLC's online panel via an email informing them of the survey and inviting them to take part. Respondents age 11–15 were recruited via emails to parents or legal guardians from the YouGov panel and asked them to read the information about the survey and pass it on to their child if they and their child consented to participation. YouGov adheres to the code of conduct set out by the Market Research Society (https://www.mrs.org.uk/pdf/mrs%20code%20of%20conduct%202014.pdf). Respondents consent to completing surveys in return for a modest financial incentive (50p for those aged 16–18, £1.50 for those aged 11–15); respondents age 11–15 also required consent from their parents or legal guardians.

2.2. Sample

The sample was designed to be nationally representative in terms of age, gender, and region. The survey was completed by 2,331 respondents age 11–18 inclusive. Respondents who had never heard of e-cigarettes (n = 159), did not report smoking status (n = 32) or e-cigarette status (n = 6), or had missing data for social grade (n = 54) were excluded from the analyses (9.8%). This left 2103 respondents (90.2%) in the study sample.

2.3. Measures

All measures included in this study, item wording, response options, and coding are listed below.

2.3.1. Harm perceptions

Relative harm perception of e-cigarettes. Participants were asked: "Compared to cigarettes, do you think e-cigarettes are more or less harmful to the person using them, or is there no difference?" (a) "Less harmful", (b) "About the same", (c) "More harmful", or (d) "Don't know". For analysis of correlates of accurate harm perceptions, responses were dichotomised as less harmful (accurate perception) (a) vs. otherwise (b–d).

Harm perception of nicotine. Participants were asked: "According to what you know or believe, how much of the harm from smoking cigarettes comes from nicotine?" (a) "None or very small", (b) "Some but well under half the risk", (c) "Around half the risk", (d) "Much more than half the risk", (e) "Nearly all the risk", or (f) "Don't know". For analysis of correlates of accurate harm perceptions, responses were dichotomized as none or very small (accurate perception) (a) vs. otherwise (b–f). This measure was adapted from Wikmans and Ramström (2010).

2.3.2. Smoking and e-cigarette status

Smoking status. Participants identified "Which ONE of the following BEST applies to you?": (a) "I have never smoked cigarettes, not even a puff or two", (b) "I have only ever tried smoking cigarettes once", (c) "I used to smoke sometimes but I never smoke cigarettes now" (d) "I sometimes smoke cigarettes now but less than one a week", (e) "I usually smoke between one and six cigarettes a week", (f) "I usually smoke more than six cigarettes a week", or (g) "Don't want to say". For analysis, responses were coded as never (a), tried (b), ex-smoker (c), sometimes (d) and at least weekly (e–f); (g) was excluded.

E-cigarette status. Participants identified "Which ONE of the following is closest to describing your experience of e-cigarettes?" (a) "I have never used an e-cigarette", (b) "I have only tried an e-cigarette once or twice", (c) "I use e-cigarettes sometimes, but no more than once a month", (d) "I use e-cigarettes more than once a month, but less than once a week", (e) "I use e-cigarettes more than once a week but not every day", (f) "I use e-cigarettes every day", or (g) "Don't want to say". For analysis, responses were coded as never (a), tried or use sometimes (b–c), and at least monthly (d–f); (g) was excluded.

2.3.3. Social norms

Family smoking. Participants were asked "Who in your family, if anyone, smokes tobacco cigarettes at the moment? Please tick all that apply" (a) Mother (or female carer)", (b) "Father (or male carer)", or (c) "Brother or sister". For analysis, respondents were coded as having at least one family member who smokes if they selected any of (a) through (c).

Family e-cigarette use. Participants were asked "And who in your family, if anyone, uses e-cigarettes at the moment? Please tick all that apply" (a) Mother (or female carer)", (b) "Father (or male carer)", or (c) "Brother or sister". For analysis, respondents were coded as having at least one family member who uses an e-cigarette if they selected any of (a) through (c).

Number of smoking friends. Participants were asked "Please think of the three friends you spend most time with. How many of them smoke tobacco cigarettes on a regular basis?" "0 (none of them)" "1", "2", "3 (all of them)", "Don't know", or "Don't want to say". For analysis, responses were coded as "0 (none of them)", "1", "2", "3 (all of them)" and don't know/refused ("Don't know", "Don't want to say").

Perceived public approval of smoking. Participants were asked "In your opinion, do people in general approve or disapprove of… People smoking tobacco cigarettes?" (a) "Strongly approve", (b) "Approve, (c) Neither approve nor disapprove, (d) "Disapprove", (e) "Strongly disapprove", or (f) "Don't know". For analysis, responses were coded as approve (a–b), neither (c), disapprove (d–e), and don't know (f).

Perceived public approval of e-cigarettes. Participants were asked: "In your opinion, do people in general approve or disapprove of… People using e-cigarettes or vaping devices?" (a) "Strongly approve", (b) "Approve, (c) Neither approve nor disapprove, (d) "Disapprove", (e) "Strongly disapprove", or (f) "Don't know". For analysis, responses were coded as approve (a–b), neither (c), disapprove (d–e), and don't know (f).

2.3.4. Demographics

Gender was recorded as male vs. female. Age was coded as 11–13 vs. 14–15 vs. 16–18. Participants' region in Great Britain was coded as North England (North East, North West, Yorkshire, East Midlands, West Midlands) vs. South England (East, South East, South West) vs. London vs. Wales/Scotland. Social grade was coded as ABC1 (higher and intermediate managerial, administrative, supervisory, clerical and junior managerial, administrative, professional occupations) vs. C2DE (skilled, semi-skilled and unskilled manual occupations, unemployed and lowest grade occupations). Social grade was based on the occupation of the chief income earner in the household and was asked of the parents of those respondents age 11–15 and directly of those respondents age 16–18.

2.4. Statistical analysis

All data were weighted to be representative of age, gender, and region using the 2015 Office for National Statistics census data. All data reported, including sample characteristics, are weighted unless otherwise stated. All analyses used STATA 15.0 (StataCorp, 2017).

To assess the prevalence of harm perceptions of e-cigarettes relative to cigarettes (aim 1a) and nicotine (aim 1b), prevalence estimates and 95% confidence intervals were calculated.

To assess correlates of accurate perceptions that e-cigarettes are less harmful than cigarettes (aim 2a), unadjusted and adjusted logistic regression analyses were used to explore the association between accurately perceiving e-cigarettes to be less harmful than cigarettes (vs. otherwise) and smoking status, e-cigarette status, demographics (gender, age, region, social grade), social norms (family smoking, family e-cigarette use, number of smoking friends, perceived public approval of smoking, perceived public approval of e-cigarettes), and accurately perceiving that none or a very small amount of the harm from smoking comes from nicotine.

To assess correlates of accurate perceptions that none or a small amount of the harm from smoking comes from nicotine (aim 2b), unadjusted and adjusted logistic regression analyses were used to explore the association between accurately perceiving none or a very small amount of harm from smoking cigarettes comes from nicotine (vs. otherwise) and smoking status, e-cigarette status, demographics and social norms (as stated previously), and accurately perceiving that e-cigarettes are less harmful than smoking.

3. Results

3.1. Sample characteristics

Approximately half of respondents were male (51.5%), the majority were from higher social grades ABC1 (68%), and 35.2% were aged 11–13 years, 25.6% aged 14–15 years, and aged 39.2% 16–18 years. Just under half (41.9%) were from North England, 33.5% from South England, 10.9% from London, and 13.8% from Wales/Scotland. The majority were never smokers (80.7%) and never e-cigarette users (87.1%).

3.2. Aim 1a: Prevalence of harm perceptions of e-cigarettes relative to cigarettes

Almost two thirds (n = 1,331, 63.4%, 95% CI = 61.1–65.6) of respondents accurately perceived that e-cigarettes were less harmful than cigarettes, while 488 (22.9%, 95% CI = 21.0–24.9) perceived they were equally as harmful, 56 (2.6%, 95% CI = 2.0–3.4) perceived they were more harmful, and 228 (11.2%, 95% CI = 9.8–12.7) didn't know.

3.3. Aim 1b: Prevalence of harm perceptions of nicotine

Only a small proportion (n = 183, 8.6%, 95% CI = 7.4–10.1) of respondents accurately perceived that none or a very small amount of the harm from smoking comes from nicotine, while corresponding values were 385 (17.7%, 95% CI = 15.9–19.6) for "some but well under half of the harm", 420 (20.0%, 95% CI = 18.1–21.9) for "half of the harm", 377 (17.9%, 95% CI = 16.2–19.7) for "much more than half of the harm", 408 (20.2%, 95% CI = 18.4–22.0) for "nearly all of the harm", and 330 (15.6%, 95% CI = 14.1–17.4) for "don't know".

3.4. Aim 2a: Correlates of the accurate perception that e-cigarettes are less harmful than cigarettes

In both adjusted and unadjusted analyses, respondents had higher odds of accurately perceiving that e-cigarettes are less harmful than cigarettes if they tried or sometimes use e-cigarettes, were older, had at least one family member who used e-cigarettes, had no smoking friends (vs. responding don't know or refusing to say), perceive that the public approve or neither approves nor disapproves of e-cigarettes, and accurately perceive that none or a very small amount of the harm from

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Table 1
Adjusted and unadjusted logistic regression analyses of the accurate perception that e-cigarettes are less harmful than cigarettes (vs. otherwise), N = 2,103.

	N[1] (% total sample)	E-cigarettes are less harmful than cigarettes (vs. otherwise)				
			Unadjusted		Adjusted[2]	
		%[1]	OR (95% CI)	p	OR (95% CI)	P
Smoking status						
Never (ref)	1634 (80.71)	61.53	1.00		1.00	
Tried	246 (10.25)	69.44	**1.42 (1.04-1.95)**	**.030**	1.00 (0.69-1.46)	.981
Ex-smoker	75 (3.57)	71.53	1.57 (0.80-3.10)	.193	1.04 (0.48-2.29)	.915
Sometimes	75 (2.67)	74.27	**1.80 (1.00-3.26)**	**.050**	1.06 (0.54-2.08)	.859
At least weekly	73 (2.81)	72.98	1.69 (0.95-3.00)	.075	1.47 (0.60-3.62)	.401
E-cigarette status						
Never (ref)	1796 (87.10)	61.41	1.00		1.00	
Tried/use sometimes	274 (11.28)	78.19	**2.25 (1.63-3.12)**	**< .001**	**1.51 (1.03-2.21)**	**.035**
At least monthly	33 (1.62)	64.72	1.15 (0.52-2.56)	.727	0.67 (0.23-2.01)	.479
Gender						
Male (ref)	966 (51.45)	65.44	1.00		1.00	
Female	1137 (48.55)	61.16	0.83 (0.69-1.01)	.061	0.86 (0.70-1.05)	.143
Age						
11-13 (ref)	698 (35.18)	55.09	1.00		1.00	
14-15	487 (25.59)	62.04	**1.33 (1.05-1.69)**	**.018**	**1.29 (1.00-1.65)**	**.049**
16-18	918 (39.22)	71.63	**2.06 (1.63-2.59)**	**< .001**	**1.89 (1.45-2.47)**	**< .001**
Region						
London (ref)	256 (10.85)	62.71	1.00		1.00	
North England	812 (41.85)	62.82	1.00 (0.73-1.38)	.976	1.10 (0.78-1.56)	.576
South England	732 (33.48)	64.82	1.10 (0.79-1.52)	.580	1.04 (0.81-1.62)	.445
Wales/Scotland	303 (13.82)	61.96	0.97 (0.67-1.41)	.867	0.98 (0.66-1.45)	.901
Social grade						
ABC1 (ref)	1432 (68.34)	63.65	1.00		1.00	
C2DE	671 (31.66)	62.73	1.42 (1.04-1.95)	.703	0.95 (0.77-1.18)	.646
Family smoking						
None (ref)	1576 (75.44)	61.74	1.00		1.00	
≥ 1 member	527 (24.56)	68.32	**1.34 (1.07-1.67)**	**.012**	1.05 (0.81-1.35)	.720
Family e-cigarette use						
None (ref)	1843 (87.46)	61.25	1.00		1.00	
≥ 1 member	260 (12.54)	78.03	**2.25 (1.62-3.12)**	**< .001**	**2.11 (1.46-3.04)**	**< .001**
Number smoking friends						
None (ref)	1629 (78.96)	63.48	1.00		1.00	
1	246 (10.45)	67.24	1.18 (0.87-1.61)	.294	0.86 (0.60-1.22)	.382
2	89 (4.11)	72.94	1.55 (0.91-2.64)	.106	0.97 (0.51-1.87)	.930
3	63 (2.57)	64.57	1.05 (0.58-1.88)	.873	0.52 (0.23-1.15)	.106
DK/Refused	76 (3.90)	39.58	**0.38 (0.23-0.61)**	**< .001**	**0.44 (0.25-0.77)**	**.004**
Public approval of smoking						
Approve (ref)	91 (3.89)	62.18	1.00		1.00	
Disapprove	1565 (75.47)	65.10	1.13 (0.71-1.81)	.596	**2.11 (1.18-3.77)**	**.011**
Neither	360 (16.34)	62.27	1.00 (0.60-1.67)	.988	1.20 (0.65-2.20)	.556
DK	87 (4.30)	37.99	**0.37 (0.20-0.71)**	**.003**	1.38 (0.57-3.37)	.477
Public approval of e-cigarettes						
Disapprove (ref)	800 (38.46)	56.33	1.00		1.00	
Approve	347 (15.95)	75.03	**2.33 (1.72-3.16)**	**< .001**	**2.44 (1.73-3.45)**	**< .001**
Neither	816 (38.59)	69.55	**1.77 (1.42-2.21)**	**< .001**	**2.01 (1.55-2.59)**	**< .001**
DK	140 (6.99)	41.18	**0.54 (0.37-0.80)**	**.002**	0.87 (0.50-1.50)	.617
How much harm from smoking comes from nicotine?						
Otherwise (ref)	1,920 (91.35)	61.69	1.00		1.00	
None or a very small amount	183 (8.65)	80.99	**2.65 (1.69- 4.14)**	**< .001**	**2.05 (1.28-3.28)**	**.003**
Constant					**0.42 (0.22-0.82)**	**.011**

DK = Don't Know. [1]N are unweighted, % are weighted. [2]Analyses are adjusted for all variables listed.

smoking comes from nicotine (Table 1). In adjusted analyses only, respondents had higher odds of accurately perceiving that e-cigarettes are less harmful than cigarettes if they perceive that the public disapproves of smoking (Table 1). Smoking status and having at least one family member who smokes were not associated with accurate relative harm perceptions of e-cigarettes in adjusted analyses (Table 1).

3.5. *Aim 2b: Correlates of the accurate perception that none or a very small amount of the harm from smoking comes from nicotine*

In both adjusted and unadjusted analyses, respondents had higher odds of accurately perceiving that none or a very small amount of the harm from smoking comes from nicotine if they were older, from Wales/Scotland compared to London, had at least one family member who smokes, and accurately perceived that e-cigarettes are less harmful than smoking (Table 2). In adjusted analyses only, respondents had

Table 2
Adjusted and unadjusted logistic regression analyses of the accurate perception that none or a very small amount of the harm from smoking comes from nicotine (vs. otherwise), N = 2,103.

	None or a very small amount of the harm from smoking comes from nicotine (vs. otherwise)				
		Unadjusted		Adjusted[2]	
	%[1]	OR (95% CI)	p	OR (95% CI)	p
Smoking status					
Never (ref)	7.47	1.00		1.00	
Tried	12.72	**1.81 (1.10-2.97)**	**.019**	1.10 (0.60-2.02)	.758
Ex-smoker	13.05	1.86 (0.77-4.49)	.167	1.01 (0.33-3.07)	.982
Sometimes	11.48	1.61 (0.70-3.69)	.262	0.74 (0.30-1.81)	.507
At least weekly	19.42	**2.99 (1.58-5.66)**	**.001**	2.25 (0.87-5.83)	.093
E-cigarette status					
Never (ref)	7.56	1.00		1.00	
Tried/use sometimes	16.78	**2.47 (1.66-3.66)**	**< .001**	1.57 (0.92-2.68)	.100
At least monthly	10.64	1.46 (0.49-4.29)	.495	0.62 (0.18-2.18)	.457
Gender					
Male (ref)	10.07	1.00		1.00	
Female	7.14	**0.69 (0.49-0.96)**	**.029**	0.72 (0.51-1.02)	.067
Age					
11-13 (ref)	4.82	1.00		1.00	
14-15	7.62	**1.63 (1.00-2.65)**	**.049**	1.52 (0.92-2.48)	.099
16-18	12.74	**4.58 (3.50-6.00)**	**< .001**	**2.60 (1.62-4.16)**	**< .001**
Region					
London (ref)	5.95	1.00		1.00	
North England	8.50	1.47 (0.81-2.66)	.203	**1.87 (1.02-3.43)**	**.043**
South England	8.27	1.43 (0.78-2.60)	.246	1.62 (0.88-3.00)	.121
Wales/Scotland	12.12	**2.18 (1.14-4.16)**	**.018**	**2.61 (1.35-5.03)**	**.004**
Social grade					
ABC1 (ref)	8.92	1.00		1.00	
C2DE	8.05	1.81 (1.10-2.97)	.539	0.81 (0.57-1.17)	.264
Family smoking					
None (ref)	7.33	1.00		1.00	
≥ 1 member	12.70	**1.84 (1.30-2.61)**	**.001**	**1.59 (1.05-2.42)**	**.030**
Family e-cigarette use					
None (ref)	7.89	1.00		1.00	
≥ 1 member	13.91	**1.89 (1.23-2.90)**	**.004**	1.42 (0.87-2.33)	.164
Number smoking friends					
None (ref)	8.15	1.00		1.00	
1	10.50	1.32 (0.83-2.12)	.246	0.86 (0.05-1.49)	.600
2	12.13	1.55 (0.80-3.03)	.195	0.72 (0.34-1.53)	.388
3	12.77	1.65 (0.74-3.69)	.224	0.60 (0.19-1.86)	.376
DK/Refused	7.25	0.88 (0.35-2.25)	.791	1.04 (0.37-2.96)	.938
Public approval of smoking					
Approve (ref)	16.66	1.00		1.00	
Disapprove	8.46	**0.46 (0.24-0.87)**	**.018**	0.69 (0.33-1.46)	.332
Neither	8.39	**0.46 (0.22-0.96)**	**.040**	0.62 (0.27-1.44)	.266
DK	5.70	**0.30 (0.11-0.85)**	**.024**	1.42 (0.45-4.42)	.548
Public approval of e-cigarettes					
Disapprove (ref)	7.91	1.00		1.00	
Approve	14.93	**2.04 (1.31-3.19)**	**.002**	1.44 (0.89-2.33)	.134
Neither	7.67	0.97 (0.65-1.43)	.867	0.85 (0.56-1.30)	.458
DK	3.77	0.46 (0.20-1.05)	.065	**0.40 (0.19-0.82)**	**.013**
Are e-cigarettes more or less harmful than smoking?					
Otherwise (ref)	4.49	1.00		1.00	
Less harmful	11.05	**2.65 (1.69- 4.14)**	**< .001**	**2.12 (1.32-3.41)**	**.002**
Constant				**0.02 (0.01-0.07)**	**.000**

DK = Don't Know. [1]% are weighted, N are the same as in Table 1. [2]Analyses are adjusted for all variables listed.

higher odds of accurately perceiving that none or a very small amount of the harm from smoking comes from nicotine if they were from the North of England compared with London but lower odds if they responded "don't know" to perceived public approval of e-cigarettes (Table 2). Gender, smoking, and e-cigarette status were not associated with harm perceptions of nicotine in adjusted analyses (Table 2).

4. Discussion

In this nationally representative sample of young people in Great Britain, as previously reported (Eastwood et al., 2017), just under two thirds (63%) have accurate harm perceptions of e-cigarettes relative to cigarettes. We also found that very few (9%) accurately perceive that nicotine causes little of the health harms of smoking. Accurate relative harm perceptions of e-cigarettes were higher among those who were older, had tried or used an e-cigarette sometimes, had at least one family member who used e-cigarettes, had no friends who smoke, perceived that the public approve or neither approves nor disapproves of e-cigarettes, and perceived that the public disapproves of smoking. Accurate harm perceptions of nicotine were higher among those who were older, had a family member who smokes, or who were unsure about whether the public approves of e-cigarettes. E-cigarette use was not associated with accurate harm perceptions of nicotine, and smoking was not associated with either harm perception. Accurate harm perceptions of e-cigarettes and nicotine were positively associated with one another, and this association was robust against all covariates included in this study.

The finding that the majority of young people accurately perceive e-cigarettes as less harmful than cigarettes, yet many still have inaccurate harm perceptions, is similar to some other studies of adults in Great Britain (Brose et al., 2015; Yong et al., 2017) and the US (Richardson et al., 2014). Harm perceptions of e-cigarettes relative to cigarettes have been reported from this dataset previously (Eastwood et al., 2017). However, the sample differed slightly, as the Eastwood et al. (2017) study involved cross-sectional data collected annually between 2013 and 2016 with respondents taking part in multiple waves and randomly assigned to one wave; the present study used all respondents from the 2016 survey. The Eastwood study also did not explore the prevalence of accurate harm perceptions of nicotine or correlates of accurate harm perceptions of e-cigarettes relative to cigarettes and nicotine.

The low prevalence rates of accurately perceiving that none or a very small amount, or even some but under half, of the harm from smoking comes from nicotine is a novel finding. A previous study among adult daily smokers from Sweden and Norway found higher rates of perceiving that none or a very small part (15%) or a relatively small part (31%) of the health risks from smoking come from nicotine (Wikmans and Ramström, 2010), yet these differences could be attributable to age, smoking status, or the availability of Snus in Sweden. Other previous studies in adults (Black et al., 2012; Borland et al., 2011) and US freshmen (Smith et al., 2007) have also found higher rates of perceiving that NRT is not harmful or less harmful than smoking (40%–80%); however, these differences could be attributable to the measures used. Black et al. (2012) assessed the harmfulness of long-term NRT use, Borland et al. (2011) of NRT relative to cigarettes, and Smith et al. (2007) of three specific NRT products relative to cigarettes. Further, as we found that accurate harm perceptions of nicotine were higher in older respondents, these differences may also be attributable to age.

The higher odds of having accurate e-cigarette harm perceptions in young people who used e-cigarettes less than monthly (vs. never users) is unsurprising and consistent with previous studies in adults (Adkison et al., 2013; Brose et al., 2015; Majeed et al., 2017; Yong et al., 2017) and young people (Ambrose et al., 2014; Amrock et al., 2015; Persoskie et al., 2017; Thrasher et al., 2016). However, there was no difference in harm perceptions among those who used e-cigarettes at least monthly (vs. never users); this is possibly due to less than 2% of respondents using at least monthly, which is reflected by the relatively wide confidence intervals for this group. The low prevalence of regular e-cigarette use is consistent with previous findings among young people in Great Britain (Bauld et al., 2017; McNeill et al., 2018).

Unlike e-cigarette harm perceptions, there was no association between accurate nicotine harm perceptions and e-cigarette use. Therefore, young people may be experimenting with e-cigarettes for reasons unrelated to harm perceptions of nicotine. This could be because not all e-cigarettes contain nicotine or because some individuals do not fully understand the role of nicotine in some e-cigarette use. However, harm perceptions of e-cigarettes and nicotine were positively associated with one another. Qualitative research and surveys including questions relating to these issues and the nicotine content in e-cigarettes may advance understanding of these findings.

Neither harm perceptions of e-cigarettes nor nicotine were associated with smoking status. This is contrary to previous studies in youth (Ambrose et al., 2014) and adults (Majeed et al., 2017), although there were several differences between those previous studies and the present study, including but not limited to different countries (US vs. UK), years of data collection, and covariates adjusted for. Longitudinal studies are necessary to assess whether accurate (or inaccurate) harm perceptions of e-cigarettes and nicotine are predictive of smoking uptake and other transitions, especially given recent debates surrounding the impact of e-cigarettes on youth smoking (Aveyard et al., 2018).

In terms of the demographic correlates, respondents who were younger had higher odds of being misinformed about harm perceptions of nicotine and e-cigarettes consistent with some previous studies (Ambrose et al., 2014; Amrock et al., 2015). There was little evidence for differences in social grade, which reflects findings in adults that there was no association between income and harm perceptions (Brose et al., 2015; Yong et al., 2017).

In terms of the social correlates, family use of e-cigarettes was associated with accurate harm perceptions of e-cigarettes. It is possible that some family members who use e-cigarettes were former smokers who overtly acknowledge the relative safety of e-cigarettes and benefits of switching. However, it may suggest that family e-cigarette use could increase the likelihood of youth e-cigarette use if perceptions translate to use, which would be of concern if youth were not smokers. On the other hand, exposure to family smoking was associated with accurate harm perceptions of nicotine (but not e-cigarettes). Number of smoking friends was not associated with harm perceptions of e-cigarettes or nicotine except responding “don't know” or refusing to answer, which was associated with less accurate harm perceptions of e-cigarettes. Future studies could explore whether friends' e-cigarette use influences harm perceptions.

This was the first study to explore the associations between public approval of e-cigarettes and smoking and harm perceptions of e-cigarettes and nicotine. Perceiving that the public approved of e-cigarettes yet disapproved of smoking was associated with accurate harm perceptions of e-cigarettes. However, public approval of these products was not associated with nicotine harm perceptions except responding “don't know” or refusing to answer.

While this study provides important insight into the harm perceptions of e-cigarettes and nicotine in young people and variables associated with them, the findings must be considered in light of several limitations. First, data are cross-sectional, and therefore it is not possible to infer causality regarding the associations between harm perceptions and use of e-cigarettes/nicotine and product use. Specifically, it cannot be inferred whether young people with accurate harm perceptions of e-cigarettes and nicotine will subsequently try or be tempted to try e-cigarettes, tobacco cigarettes, and other nicotine products. Second, it is not possible to say whether these results generalise to other countries, and the generalisability of the findings to Great Britain may be limited as 10% of the sample was excluded due to having not heard of e-cigarettes or having missing data on key variables. Third, the data are from one time point in March-April 2016, and therefore caution must be exercised if attempting to generalise these findings over time, as harm perceptions are likely to be changing with the continued emergence of research, reports and media stories, and implementation of new laws and regulations (Brose et al., 2015). Fourth, consistent with other findings in Great Britain (Bauld et al., 2017; McNeill et al., 2018), rates of regular smoking and regular e-cigarette use were low, which may result in low power when drawing comparisons between these behaviours and harm perceptions. Low numbers of smokers and e-cigarette users also did not allow for exploration of dual use, which may be differentially associated with harm perceptions compared with exclusive use of either product. Fifth, the measure of nicotine harm perceptions could have been misinterpreted. While most of the health harms of smoking are caused by tobacco constituents other than nicotine, nicotine sustains smoking addiction (Benowitz, 2009) and may therefore be seen to increase exposure to toxicants. Indeed, Black et al. (2012) found that the most commonly reported harm of NRT was addiction. Future studies among young people should consider specific questions pertaining to the harm perceptions of nicotine in causing specific diseases such as cancers (as in Borland et al., 2011) and distinguish those from concerns about addiction and addiction promoting sustained tobacco use.

Despite these limitations, this study has important strengths. It is the first to assess prevalence rates of the harm perception of nicotine and the first to explore correlates of harm perceptions of e-cigarettes and nicotine among young people in Great Britain. Further, the sample was drawn from the general population in Great Britain using a quota sampling approach and subsequently weighted to enhance representativeness.

In conclusion, many young people in Great Britain have inaccurate harm perceptions of e-cigarettes and nicotine. E-cigarette use was associated with accurate harm perceptions of e-cigarettes but not nicotine, while smoking was not associated with either harm perception. Greater understanding of how these harm perceptions influence use of and transitions between e-cigarettes, tobacco cigarettes, and other nicotine products among both smokers and never smokers is needed. While some demographic groups may be more vulnerable to misinformation, specifically younger individuals, continued surveillance of harm perception in addition to nuanced information about e-cigarettes, nicotine, and smoking is essential for all.

Contributors

HC and DA designed the survey, with input from AM, LB and SH. KE led the data analysis and write-up of the manuscript, with significant input from SH, LB and AM. All authors contributed to revisions of the manuscript and approved its final version.

Conflict of interest

All authors declare no conflicts of interest.

Role of the funding source

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5.3. Discussion in relation to this thesis

In my publication above I assessed (i) the prevalence of harm perceptions of (a) vaping, and (b) nicotine, relative to smoking, and (ii) correlates of accurate harm perceptions of (a) vaping, and (b) nicotine, relative to smoking, using nationally representative cross-sectional data from British youth age 11-18 [2]. Correlates included smoking and vaping norms, smoking and vaping status, and demographic variables [2]. The focus of this discussion is on the social norms findings [2].

I found that most (63%) British youth accurately perceived that vaping was less harmful than smoking, while few (9%) accurately perceived that none or a very small amount of the harm from smoking comes from nicotine [2]. Having family members who vape and perceiving that the public approve of vaping but disapprove of smoking were positively associated with accurately perceiving that vaping is less harmful than smoking [2]. Having a family member who smokes was associated with accurate harm perceptions of nicotine [2].

My findings [2] were somewhat consistent with theories such as the Health Belief Model, which propose that social factors help to shape risk perceptions surrounding a behaviour which in turn predict behaviour itself [81, 168]. My findings [2] were also consistent with previous research that has found that youth with family members who use a tobacco product or vape were more likely to perceive vaping as less than or equally harmful than smoking [171]. Associations between family member vaping and accurate harm perceptions of vaping relative to smoking could possibly be explained by discussions of the harms of vaping compared to smoking in households with parents or siblings who vape.

To my knowledge, associations between smoking and vaping norms and harm perceptions of nicotine had not been assessed prior to my publication in Chapter 5 [2]. Again consistent with the Health Belief Model [81, 168], I found that having family members who smoke was positively associated with accurately perceiving that none or a small amount of the harm from smoking comes from nicotine [2]. As above, associations between family member smoking and accurate harm perceptions of nicotine could be explained by discussions of the harms of smoking and nicotine in households with parents or siblings who smoke. However, counter to the Health Belief Model [81, 168], I did not find any other associations between smoking and vaping norms, or smoking and vaping behaviours, and nicotine harm perceptions, when adjusting for covariates [2].

Considering the unadjusted results, in this Chapter I found that family smoking increased the odds of having accurate harm perceptions of vaping, but only in the absence of other covariates, including family vaping [2]. Similarly, family vaping only increased the odds of having accurate relative harm perceptions of nicotine in the absence of other covariates, including family smoking [2]. As discussed above in Chapter 4 (Section 4.3) [1], there is likely to be confounding between the smoking and vaping behaviours of family members. Such confounding requires consideration in future studies.

Interestingly, I found that perceiving that the public *approve* of vaping but *disapprove* of smoking were associated with having accurate harm perceptions of vaping [2]. As mentioned in Section 1.4.6.2 above, it is possible that the availability of a reduced harm nicotine product could denormalise smoking by reducing how acceptable smoking is perceived to be. My findings [2] indeed suggest that awareness that vaping is less harmful than smoking could potentially reduce the perceived public approval of smoking. However, further longitudinal research would be required to assess this claim.

It is important to note that these data were cross-sectional and therefore the direction of associations is unclear. Longitudinal studies exploring temporality of the associations between smoking and vaping norms, harm perceptions, and behaviour are required to understand the mechanisms through which all three are related. This is essential to inform models such as the Health Belief Model [168] and also to help understand whether changing harm perceptions of vaping and nicotine could change social norms surrounding vaping and smoking.

5.3.1. Conclusion

In this Chapter (Chapter 5) I found that most (63%) British youth accurately perceived that vaping is less harmful than smoking, while few (9%) accurately perceived that none or a small amount of the harm from smoking comes from nicotine [2]. Consistent with theories that propose that norms shape perceptions of risk surrounding a behaviour [168], I found that accurate harm perceptions of vaping were generally associated with more positive vaping norms but less positive smoking norms [2]. Family smoking was also associated with accurate harm perceptions of nicotine [2]. However, the cross-sectional nature of this data mean that the direction of the associations cannot be determined.

5.4. Impact and dissemination

My publication above [2] has been cited in reports by Public Health England [31] and Cancer Council Victoria [254], which are used to inform policy in the UK and Australia, respectively. My publication also forms part of a larger body of evidence led by ASH, monitoring and evaluating smoking and vaping behaviours and attitudes among British youth. As of 24th September 2019, my publication [2] had been cited six times. I presented this work as a poster at the Society for the Study of Addiction (SSA) 2016 Annual Meeting in York, England (poster available online at [7]).

CHAPTER 6

Smoking and Vaping Norms Among Youth Across England, Canada, US

6.1. Preface

This thesis also explores whether smoking and vaping norms differ across countries with different smoking and vaping policies and prevalence rates. Social norms towards smoking have been theorised to be on the pathway between tobacco control policies and reductions in smoking prevalence [58-62]. For example, smoke-free legislation is said to denormalise smoking, and reduce smoking prevalence [57]. Smoking should therefore be perceived as less common and approved of in countries with stronger tobacco control policies and lower smoking prevalence rates. Similarly, vaping should be perceived as less common and approved of in countries with more restrictive vaping policies and lower vaping prevalence rates.

In this Chapter I extended my findings from Chapter 4, which assessed the longitudinal associations between smoking and vaping norms and smoking and vaping initiation among British youth age 11-18 [1], to assess the cross-sectional associations between smoking and vaping norms and (i) country, (ii) smoking status, and (iii) vaping status among youth age 16-19 from England, Canada, and the US.

These objectives relate to *Aims 1-3* and *6-7* of my thesis: To assess, among youth, the associations between smoking norms and smoking behaviours *(Aim 1)*, vaping norms and vaping behaviours *(Aim 2)*, vaping norms and smoking behaviours, and smoking norms and vaping behaviours *(Aim 3)* and to assess, among youth (and adult smokers), whether smoking norms correspond with tobacco control policies and smoking prevalence rates *(Aim 6)* and vaping norms correspond with vaping policies and vaping prevalence rates *(Aim 7)*.

I addressed these objectives, and hence thesis aims, in my third peer-reviewed publication, which is presented in Section 6.2 below [3]:

> *East, K., Hitchman, S. C., McNeill, A., Thrasher, J. F., Hammond, D. (in press). Social norms towards smoking and vaping and associations with product use among youth in England, Canada, and the US. Drug and Alcohol Dependence.*

I have provided this publication as the authors' accepted manuscript because it was in press at the time of my thesis submission [3]. I have provided a discussion contextualising the findings of my publication [3] into this thesis, in Section 6.3. I have also included a summary of the impact and dissemination of this work, in Section 6.4.

6.1.1. Declaration of roles

I developed this publication [3] in collaboration with Dr Sara C Hitchman and Professor Ann McNeill (King's College London), Professor James F Thrasher (The University of South Carolina) and Professor David Hammond (The University of Waterloo). DH was the Principal Investigator of the International Tobacco Control Policy Evaluation (ITC) Project Youth Tobacco and E-Cigarette Survey and designed the survey with the survey firm Nielsen. Nielsen were responsible for sample recruitment and maintenance. SCH, AM, and JFT provided input on the survey design and measures. I also provided input on the measures, particularly the smoking and vaping norms measures which were informed by my previous work [15]. I led the write-up of the publication [3], formulated the research questions, and analysed the data, with input from SCH and AM. All co-authors reviewed and provided input on drafts of the publication [3].

6.1.2. Selection of social norms measures

In this publication [3] I used data from the 2017 ITC Project Youth Tobacco and E-Cigarette Survey [227]. I selected two measures of smoking norms and two measures of vaping norms for use in this publication [3]: friend smoking, perceived peer approval of smoking, friend vaping, perceived peer approval of vaping (see Table 3.1).

I selected these four social norms measures because during my PhD there were concerns about the popularity of vaping among youth, particularly in the US [35, 50]. Peer group influences were thought to play an important role in youth vaping [35, 50]. These measures also allowed for assessment of both descriptive and injunctive norms. There were constraints on the number of measures that could be included in the ITC Project Youth Tobacco and E-Cigarette Survey, and the inclusion and wording of all social norms measures were also based on discussions with co-authors and the ITC Project Youth Tobacco and E-Cigarette Survey team. The wording of some social norms measures in this Chapter therefore differed from other Chapters in this thesis.

6.2. Accepted manuscript

Social Norms Towards Smoking and Vaping and Associations with Product Use Among Youth in England, Canada, and the US

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Abstract

Background: This study assesses differences in social norms towards smoking and vaping among youth across countries (England, Canada, US) and smoking and vaping status.

Methods: Data are from the 2017 ITC Youth Tobacco and Vaping Survey, among youth age 16-19 in England (N=3,444), Canada (N=3,327), and US (N=3,509). Prevalence of friend smoking, friend vaping, peer approval of smoking, and peer approval of vaping were estimated. Adjusted logistic regression models were estimated for each norm to assess associations with country, smoking status, and vaping status, adjusting for sociodemographics, alcohol use, and marijuana use.

Results: 47% and 52% reported friend smoking and vaping respectively. Perceived peer approval of vaping (44%) was almost double that of smoking (23%). Compared with England, fewer Canadian and US youth reported friend smoking (Canada: AOR=0.71 [95% CI=0.62-0.82]; US: AOR=0.54 [0.47-0.62]) and peer approval of smoking (Canada: AOR=0.74 [0.63-0.87]; US: AOR=0.78 [0.67-0.91]), yet more reported peer approval of vaping (Canada: AOR=1.23 [1.08-1.41]; US: AOR=1.30 [1.14-1.48]). More Canadian than English youth reported friend vaping (AOR=1.17 [1.02-1.36]). Friend smoking, peer approval of smoking, and friend vaping were more common among smokers and vapers (all $p<.02$). Peer approval of vaping was more common among vapers but less common among smokers (all $p<.044$).

Conclusions: Youth had more positive vaping than smoking norms. English youth reported the most pro-smoking but least pro-vaping norms in adjusted models; this was unexpected given country differences in regulatory environments. Norms towards both products were associated with use, with some evidence of cross-product associations between norms and behaviours.

Keywords: Electronic cigarettes; Vaping; Smoking; Social Norms; Youth; Survey

1. Introduction

Tobacco smoking is the leading preventable cause of death and disease worldwide, killing over seven million people annually (World Health Organization [WHO], 2018). In many countries, increasingly comprehensive tobacco control policies have been implemented with the aim of "denormalising" smoking and reducing smoking prevalence (Chapman and Freeman, 2008; Dubray et al., 2015). However, the nicotine market has changed with the introduction of vaping devices (also called e-cigarettes; Hon, 2003) and there has been considerable discussion with regards to the impact of vaping on smoking norms and behaviour. Vaping devices have the potential to reduce the harms caused by smoking and may help some smokers quit (Hajek et al., 2019; McNeill et al., 2019). However, concerns have been expressed that e-cigarettes might "renormalise" and promote smoking, particularly among youth (Aveyard et al., 2018; Sæbø and Scheffels, 2017; The European Parliament and the Council of the European Union, 2014; U.S. Department of Health and Human Services, 2016). Studies are therefore needed to assess social norms towards smoking and vaping among youth, particularly cross-product associations between norms and behaviour.

Social norms can be classified into two domains: descriptive and injunctive. Descriptive norms refer to perceptions of how others behave (e.g., friend smoking), while injunctive norms refer to perceptions of what others think people should or should not do (e.g., peer approval of smoking) (Borsari and Carey, 2003; Cialdini et al., 1991). Associations between descriptive and injunctive norms and youth smoking are well documented: youth who have more friends or peers who smoke (Chang et al., 2006; Conner et al., 2017; Lotrean et al., 2013) or who perceive greater approval of smoking among parents, friends, or peers (Chang et al., 2006; Lotrean et al., 2013; Van De Ven et al., 2007) are more likely to initiate smoking. Moreover, cross-sectional studies in the US and Mexico have found that youth with friends who vape and who perceive acceptability of vaping among peers are more susceptible to (i.e., open to trying in the next year), and more likely to actually try, vaping (Gorukanti et al., 2017; Lozano et al., 2019; Thrasher et al., 2016).

It is less clear whether there are cross-product influences of norms on product use. In Mexico and Argentina, friend smoking was more common among youth who have tried and are susceptible to vaping (Lozano et al., 2019; Morello et al., 2016; Thrasher et al., 2016); however, no association was found between friend vaping, or perceived social acceptability of vaping, and smoking susceptibility (Lozano et al., 2019). Contrastingly, a longitudinal study in Britain found that youth with vaping friends had greater odds of initiating vaping but lower odds of initiating smoking, while those who perceived public approval of smoking had lower odds of initiating vaping (East et al., 2018). It is therefore possible that norms towards one product may suppress, rather than promote, use of the alternative. Further research is required to corroborate these findings, particularly across countries with different smoking and vaping environments.

Research suggests adult smokers and ex-smokers from countries with stronger tobacco control policies have more anti-smoking injunctive norms (Hammond et al., 2006; Kasza et al., 2017), while those from countries with less restrictive vaping policies have more pro-vaping norms (Aleyan et al., 2019). By contrast, a recent survey of smokers in Europe (East et al., 2019) found that while friend smoking was more common in countries with greater smoking prevalence and weaker tobacco control policies, approval of smoking was not, and friend vaping and approval of vaping showed little obvious relation to vaping prevalence or policies. However, adult smokers and ex-smokers likely have unique norms towards smoking, and there is no research of which we are aware comparing smoking and vaping norms across countries among youth.

This study therefore assesses whether social norms towards smoking and vaping are associated with country, smoking status, and vaping status among 16-19-year-olds in Canada, England, and the US. At the time of surveying, prevalence of ever smoking and ever vaping among 16-19-year-olds were lowest in Canada but similar in England and the US (Hammond et al., 2019). England and Canada had more comprehensive tobacco control policies than the US, having implemented comprehensive smokefree legislation, retail display bans, bans on tobacco advertising, and mandated graphic health warnings on cigarette packs (ITC, 2018; WHO, 2017a-c). Canada had more restrictive policies on the sale, use, and advertisement of vaping devices than England and the US (Gravely et al., 2019; ITC, 2018), although these were generally unenforced (Hammond et al., 2015).

2. Methods

2.1. Design

A full description of the methods can be found in Hammond et al. (2018). Briefly, data were from Wave 1 (July/August 2017) of the International Tobacco Control Policy Evaluation Project (ITC) Youth Tobacco and Vaping Survey, an online survey of 16-19-year-olds in England, Canada, and US. Respondents were recruited through Nielsen Consumer Insights Global Panel (and partners' panels) directly or through their parents. Email invitations were sent to a random sample of panellists after targeting for age criteria. Panellists not aged 16-19, had no children aged 16-19, and/or were attempting to complete the survey on a mobile device were ineligible to partake. The survey was in English, and French in Canada, and took approximately 15 minutes. The same measures were used in all countries except ethnicity, region, and education, which were based on country census questions. Informed consent was required, and respondents received remuneration according to their panel's incentive structure. Ethical clearance was received from the University of Waterloo Research Ethics Committee (AORE#21847) and King's College London's Psychiatry, Nursing & Midwifery Research Ethics Subcommittee (PNM-RESC-HR-16/17-4113).

2.2. Sample

The survey was completed by 13,468 youth age 16-19-years, of which 10,280 were retained for this study. The following were excluded: those who provided incomplete/invalid data on smoking/vaping status or other variables used for weighting (n=1,120), failed data quality checks (n=382), did not report or responded "Don't know" to friend smoking (n=343), friend vaping (n=309), peer approval of smoking (n=316), peer approval of vaping (n=718).

2.3. Measures

2.3.1. Social norms (outcomes)

Friend smoking: "Who, if anyone… smokes cigarettes?", followed by a list of people. Respondents who checked "Your friend(s)" were coded as having friends who smoke.

Friend vaping: "Who, if anyone… uses e-cigarettes/vapes?", followed by a list of people. Respondents who checked "Your friend(s)" were coded as having friends who vape.

Peer approval of smoking: "Do people your age approve or disapprove of smoking cigarettes?" (a) Strongly approve, (b) Somewhat approve, (c) Neither approve nor disapprove, (d) Somewhat disapprove, (e) Strongly disapprove. (a)-(b) were coded as approve; (c)-(e) were coded as not approve.

Peer approval of vaping: "Do people your age approve or disapprove of using e-cigarettes/vaping?" (a) Strongly approve, (b) Somewhat approve, (c) Neither approve nor disapprove, (d) Somewhat disapprove, (e) Strongly disapprove. (a)-(b) were coded as approve; (c)-(e) were coded as not approve.

Coding of (iii) and (iv) is consistent with similar studies (Lozano et al., 2019; East et al., 2019).

2.3.2. Smoking and vaping status

Smoking status: Current (smoked 100+ cigarettes in life and smoked in past-30-days), experimental (tried smoking, but did not smoke 100+ cigarettes in life), former (smoked 100+ cigarettes in life, but did not smoke in past-30-days), never (never tried smoking, not even a puff) (Hammond et al., 2018).

Vaping status: Current (vaped 100+ days in life and vaped in past-30-days), experimental (tried vaping, but did not vape 100+ days in life), former (vaped 100+ days in life, but did not vape in past-30-days), never (never tried vaping, not even a puff) (Hammond et al., 2018).

2.3.3. Covariates

Covariates included age (16-19), sex (male, female), ethnicity (white, other/mixed, don't know/refused), current student (yes, no, don't know/refused), monthly alcohol use (yes, no, don't know/refused), past-30-day marijuana use (yes, no, don't know/refused), and two socio-economic status indicators: number of computers in household (0-2, ≥3, don't know/refused), number of bathrooms in household (0-1, ≥2, don't know/refused) (Hartley et al., 2013).

2.4. Analyses

All analyses were conducted using Stata v15. First, sample characteristics were examined in each country. Second, prevalence of each social norm was estimated. Third, four separate adjusted logistic regression models were estimated for each social norm to assess associations with country, smoking status, vaping status, and covariates. Fourth, interactions between country and smoking status, and country and vaping status, were added as separate additional steps to the fully adjusted models. For interactions, experimental and former smokers, and experimental and former vapers, were combined due to low numbers of former smokers and former vapers. Adjusted Wald tests were performed on the interaction terms following model specification; where there was evidence for an interaction ($p \leq .05$) average predicted probabilities and pairwise comparisons were generated using Stata's margins command. All analyses use weighted data unless otherwise indicated, with sample weights constructed based on smoking status, region, language (Canada), sex, age, ethnicity, and using a raking algorithm described in Hammond et al. (2018).

3. Results

3.1. Sample characteristics

Most participants were 18, male, white, students, did not use alcohol monthly (except England), did not use marijuana in the past-30-days, had ≥3 computers and ≥2 bathrooms (except England) in household, and had never smoked or vaped (Table 1).

3.2. Prevalence of each social norm

Across all three countries, 46.7% and 51.6% had friends who smoked and vaped respectively. Peer approval of smoking (23.1%) was just over half that of peer approval of vaping (44.3%). Prevalence of smoking and vaping norms in each country is shown in Tables 2 and 3, respectively.

3.3. Associations between each social norm and country, smoking status, vaping status, and covariates

3.3.1. Friend smoking

Respondents had greater odds of reporting that their friends smoke if they were from England (vs. Canada and US), former, experimental or current (vs. never) smokers, experimental (vs. never) vapers, age 19 (vs. 16), other/mixed ethnicity, students (vs. don't know/refused), monthly alcohol users, or past-30-day marijuana users (Table 2). Respondents also had greater odds of reporting that their friends smoke if they were from Canada vs. US (AOR=1.32[95% CI=1.15-1.51], p<.001) or were current vs. experimental smokers (AOR=3.10[2.22-4.31], p<.001); there was little evidence for any other differences by smoking or vaping status (all p≥.055).

3.3.2. Friend vaping

Respondents had greater odds of reporting that their friends vape if they were from Canada (vs. England), experimental (vs. never) smokers, former, experimental or current (vs. never) vapers, age 17-19, other/mixed ethnicity, monthly alcohol users, or past-30-day marijuana users (Table 2). Respondents also had greater odds of reporting that their friends vape if they were current vs. experimental vapers (AOR=4.30[1.71-10.80], p=.002); there was little evidence for any other differences by country, smoking or vaping status (all p≥.126).

Post-hoc analyses were used to explore which covariates contributed to higher adjusted odds of friend vaping in Canada compared with England, despite little difference in raw prevalence (Table 2). Unadjusted logistic regressions (data not shown) found little evidence for country differences in friend vaping (all p≥.103). Excluding smoking and alcohol use from the fully-adjusted model attenuated the difference between Canada and England (all p≥.057). Exclusion of other variables did not influence interpretation of results.

3.3.3. Peer approval of smoking

Respondents had greater odds of perceiving that their peers approve of smoking if they were from England (vs. Canada and US), experimental or current (vs. never) smokers, experimental or current (vs. never) vapers, 16 (vs. 18), female, other/mixed ethnicity, did not know or refused to state their monthly alcohol use, were past-30-day marijuana users, or had 0-2 computers in their household (Table 3). There was little evidence for any other differences between Canada and US or by smoking or vaping status (all p≥.162).

3.3.4. Peer approval of vaping

Respondents had greater odds of perceiving that their peers approve of vaping if they were from Canada or US (vs. England), never (vs. experimental and current) smokers, former, experimental or current (vs. never) vapers, female, other/mixed ethnicity, or had 0-1 bathrooms in their household (Table 3). Respondents also had greater odds of perceiving that their peers approve of vaping if they were experimental vs. current smokers (AOR=1.33[1.05-1.69], p=.017) or were current vs. experimental vapers (AOR=1.86[1.23-2.80], p=.003). There was little evidence for any other differences between Canada and US or by smoking or vaping status (all p≥.080).

3.4. Interactions between country and smoking and vaping status

3.4.1. Friend smoking

There was little evidence of an interaction between country and smoking (F(4,10276)=2.37, p=.0502) or vaping (F(4,10276)=2.04, p=.086) status.

3.4.2. Friend vaping

There was an interaction between country and smoking status (F(4,10276)=6.27, p<.001; Figure 1 (i) (a)). In US, friend vaping was higher among experimental/former (AOR=1.11[1.07-1.16], p<.001) and current

(AOR=1.15[1.04-1.28], p=.008) vs. never smokers. There was little evidence of any other differences (all p≥.176).

There was also an interaction between country and vaping status (F(4,10276)=9.64, p<.001; Figure 1 (i) (b)). In England and US, friend vaping was highest among current vapers (vs. experimental/former: England: AOR=1.29[1.19-1.39], p<.001; US: AOR=1.13[1.07-1.20], p<.001; vs. never: England: AOR=1.78[1.66-1.91], p<.001; US: AOR=1.85[1.75-1.95], p<.001) followed by experimental/former vapers (vs. never: England: AOR=1.38[1.32-1.45], p<.001; US: AOR=1.63[1.57-1.69], p<.001). In Canada, friend vaping was higher among experimental/former (AOR=1.49[1.42-1.56], p<.001) and current (AOR=1.59[1.35-1.87], p<.001) vs. never vapers only (experimental/former vs. current p=.422).

3.4.3. Peer approval of smoking

There was an interaction between country and smoking status (F(4,10276)=4.74, p=.001; Figure 1 (ii) (a)). In England, peer approval of smoking was higher among current vs. experimental/former smokers (AOR=1.08[1.00-1.17], p=.044). In US, peer approval of smoking was higher among both experimental/former (AOR=1.08[1.04-1.13], p<.001) and current (AOR=1.09[1.00-1.19], p=.042) vs. never smokers. There was little evidence of any other differences (all p≥.132).

There was some evidence for an interaction between country and vaping status (F(4,10270)=2.40, p=.048; Figure 1 (ii) (b)). In Canada, peer approval of smoking was higher among experimental/former vs. never vapers (AOR=1.09[1.04-1.15], p<.001). In US, peer approval of smoking was higher among experimental/former (AOR=1.12[1.07-1.16], p<.001) and current (AOR=1.15[1.02-1.31], p=.026) vs. never vapers. There was little evidence of any other differences (all p≥.075).

3.4.4. Peer approval of vaping

There was an interaction between country and smoking status (F(4,10276)=8.60, p<.001; Figure 1 (iii) (a)). In England, peer approval of vaping was lowest among current smokers (vs. experimental/former: AOR=0.93[0.87-1.00], p=.045; vs. never: AOR=0.83[0.78-0.89], p<.001) followed by experimental/former smokers (vs. never: AOR=0.90[0.86-0.93], p<.001). In Canada, peer approval of vaping was lower among current (AOR=0.87[0.79-0.95], p=.002) and experimental/former (AOR=0.92[0.87-0.97], p=.002) vs. never smokers. There was little evidence of any other differences (all p≥.201).

There was also an interaction between country and vaping status (F(4,10276)=5.29, p<.001; Figure (iii) (b)). In England and Canada, peer approval of vaping was higher among current (England: AOR=1.27[1.06-1.52], p=.009; Canada: AOR=1.24[1.04-1.47], p=.016) and experimental/former (England: AOR=1.13[1.08-1.19], p<.001; Canada: AOR=1.16[1.10-1.22], p<.001) vs. never vapers. In US, peer approval of vaping was highest among current vapers (vs. experimental/former: AOR=1.20[1.09-1.32], p<.001; vs. never: AOR=1.53[1.39-1.69], p<.001) followed by experimental/former vapers (vs. never: AOR=1.28[1.22-1.34], p<.001).

4. Discussion

This study is the first to our knowledge to assess country differences in social norms towards smoking and vaping among youth and associations with product use. Overall, youth had more pro-vaping than pro-smoking norms. English youth reported the most pro-smoking and least pro-vaping norms overall. Norms were similar in Canada and the US, except more Canadian than US youth reported friend smoking. Smokers had more pro-smoking norms, vapers had more pro-vaping norms, and there were some cross-product associations between norms and use.

Prevalence of friend use of either product was similar overall, with around half of youth reporting friend smoking (47%) and friend vaping (52%), while perceived peer approval of vaping (44%) was almost twice that of peer approval of smoking (23%). Friend smoking and vaping was greater than previous British (East et al., 2018) and US (Barrington-Trimis et al., 2016; Gorukanti et al., 2017) studies, possibly due to the older age of participants in this study. To our knowledge, perceived peer approval of smoking and vaping have not been simultaneously assessed in other studies. The finding that peer approval of vaping was greater than smoking is perhaps unsurprising given that vaping is less harmful than smoking (McNeill et al., 2015) and may be more appealing to youth than smoking given the novelty and range of products and flavours available.

The high prevalence of friend product use and perceived peer approval of vaping is concerning, particularly given the age of respondents, that the majority had never smoked or vaped, and that norms were associated with use. There are concerns that the popularity of vaping may lead never smoking youth to try nicotine (U.S. Department of Health and Human Services, 2016). Between 2017 and 2018, prevalence of vaping increased in Canada and the US, including among never smokers, but did not change in England (Hammond et al., 2019); this mirrors our findings that vaping norms were most positive in the former two countries. It is important that norms are continuously monitored alongside prevalence to explore whether pro-vaping norms could precede any changes in vaping, or smoking.

Friend smoking and peer approval of smoking were more commonly reported by smokers, adding to the large body of evidence that smoking norms influence smoking behaviour (Chang et al., 2006; Chapman and Freeman, 2008; Conner et al., 2017; Lotrean et al., 2013; Van De Ven et al., 2007). Friend vaping and peer approval of vaping were more commonly reported by vapers, also similar to previous studies (Gorukanti et al., 2017; Lozano et al., 2019; Thrasher et al., 2016). Interestingly, there was a strong dose-response association between greater vaping behaviour and pro-vaping norms in all countries which was not mirrored for smoking.

Considering cross-product norm-behaviour associations, friend smoking, friend vaping, and peer approval of smoking were more common among smokers and vapers, while peer approval of vaping was more common among vapers but less common among smokers. This suggests associations between norms and behaviour may not be product-specific, although generally product-specific associations were stronger than cross-product associations, particularly for friend smoking and vaping. Except the association between vaping and friend smoking (Lozano et al., 2019; Morello et al., 2016; Thrasher et al., 2016), the direction of associations is inconsistent with previous studies (East et al., 2018; Lozano et al., 2019). This, combined with the mixed positive and negative associations between norms towards one product and use of the alternative, precludes any firm conclusions regarding the potential of e-cigarettes to renormalise smoking. Further research assessing specific norm-behaviour pathways using longitudinal methodology is needed.

Both friend smoking and vaping were more common among youth who used alcohol monthly and were older, although increases in friend vaping emerged earlier than friend smoking. Both peer approval of smoking and vaping were more common among females, and generally all norms were more positive among marijuana users (except peer approval of vaping) and ethnic minorities. Thus, there may be some shared risk factors for holding positive smoking and vaping norms.

The country differences in smoking and vaping norms were surprising. English youth reported more pro-smoking norms than the US despite similar smoking rates (Hammond et al., 2019) and the US having less comprehensive tobacco control policies (ITC, 2018; WHO, 2017a-c). Moreover, friend smoking was higher in Canada than the US, yet peer approval of smoking was similar, contrary to Canada's lower smoking prevalence (Hammond et al., 2019; WHO, 2015) and more comprehensive tobacco control policies (ITC, 2018; WHO, 2017a-c). However, the finding that English youth reported more pro-smoking norms than Canadian youth does align with prevalence rates (Hammond et al., 2019; WHO, 2015), Canada's longer history of tobacco control policies (Hammond et al., 2006; ITC, 2018; WHO, 2017a-c), and a recent study among adult daily smokers (East et al., under review).

Canada and the US had more pro-vaping norms than England in adjusted analyses, while Canada and the US did not differ. However, at the time of surveying, Canada had the lowest vaping prevalence among this age group (Hammond et al., 2019) and the most restrictive vaping policies (Gravely et al., 2019; ITC, 2018). These results may suggest that vaping policies or prevalence rates may have less influence on social norms than some might suppose, reflecting findings from a recent study in Europe (East et al., 2019) yet contrary to findings among adult smokers and ex-smokers in England, Canada, the US, and Australia (Aleyan et al., 2019).

The discrepancy between the unadjusted and adjusted country differences in friend vaping warrants further exploration. Despite the adjusted odds of friend vaping being higher in Canada than England, exclusion of smoking and alcohol use attenuated country differences. However, inclusion of alcohol, and marijuana, use is important in studies assessing youth smoking and vaping, since they may serve as a proxy for risky behaviour that confounds apparent associations (Kozlowski and Warner, 2017).

It is important to mention that while tobacco control policies in 2017 were generally least comprehensive in the US, and vaping policies most restrictive in Canada, the detailed picture is more complicated. Canada's vaping restrictions were generally unenforced (Hammond et al., 2015) and after survey administration Canada implemented a new Vaping Products Act which relaxed many restrictions (Health Canada, 2018). Further, some youth also use vaping devices for marijuana or cannabis oil (Cassidy et al., 2018; Thurtle et al., 2017) and around the time of survey administration recreational marijuana use was legalised in Canada and several US states. Both the new Act and marijuana legalisation were widely discussed around the time of this survey and may have influenced vaping norms; however, this is only speculation and would be difficult to assess. In addition to national smoking/vaping policies, Canada and the US also have divergent municipal/state/province-level policies (e.g., smokefree legislation, minimum age for legal purchase of nicotine products (US: 18-21; Canada: 18-19)). Moreover, since these data were collected in 2017, vaping environments have changed in Canada and the US: while Canada has relaxed many restrictions (Health Canada, 2018), the US has launched a national youth vaping prevention campaign (Food and Drug Administration, 2019) and proposed banning vaping in some jurisdictions (City Attorney of San Francisco, 2019). Youth vaping prevalence has also increased in these two countries since 2017 (Hammond et al., 2019). Therefore, while this study provides an overview of norms in each country, they may differ at the municipal/state/province-level and may not be generalisable to more recent years.

The findings from this study must be considered in light of several limitations. First, data were cross-sectional, meaning that directionality cannot be inferred, and there is almost certainly a reciprocal relationship between norms and behaviour. Second, smoking norms may confound vaping norms and vice-versa; for example, some youth could have pro-vaping norms *because* they have anti-smoking norms. Future research could assess within-person differences in smoking/vaping norms and their associations with product use. Third, item wording for friend use does not enable differentiation between those with only one smoking/vaping friend and those among whom all friends smoke/vape. Fourth, data were self-reported and may be subject to recall and social desirability biases, which may be particularly pronounced when asking about peer's nicotine use and norms. However, the fact that this was an anonymous, self-administered survey may alleviate some of this concern. Fifth, as mentioned above, Canada and the US have differing policies at the municipal/state/province-level which were not accounted for in analyses.

Despite these limitations, this study has important strengths. First, although participants were recruited from non-probability-based commercial samples, sample weights were incorporated to enhance representativeness and both weighted and unweighted estimates were similar to national benchmark surveys in each country (Hammond et al., 2018). Second, the sample was large, allowing for assessment of different user status groups and interactions with country. Third, this study is the first to compare social norms towards smoking and vaping and their associations with product use across countries, providing a novel contribution to the literature.

5. Conclusions

Around half of youth reported having friends who smoke and vape. Perceived peer approval of vaping (44%) was twice that of peer approval of smoking (23%). English youth had the most pro-smoking norms but least pro-vaping norms overall, contrary to regulatory environments. Consistent with previous research, smokers reported more pro-smoking norms while vapers reported more pro-vaping norms. There were also cross-product associations between norms and behaviour, although product-specific associations were stronger than cross-product associations.

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Table 1. Sample characteristics by country

	Unweighted n (weighted %)		
	England (N=3,444)	Canada (N=3,327)	US (n=3,509)
Age			
16	512 (18.82)	503 (19.15)	736 (22.29)
17	856 (29.80)	775 (27.30)	777 (23.54)
18	1226 (30.04)	1087 (29.95)	1105 (30.48)
19	850 (21.34)	962 (23.59)	891 (23.69)
Sex			
Male	1456 (54.96)	1132 (50.90)	1376 (53.40)
Female	1988 (45.04)	2195 (49.10)	2133 (46.60)
Ethnicity			
White	2720 (79.57)	1818 (59.46)	2322 (74.02)
Other/mixed	696 (19.58)	1459 (39.22)	1171 (25.54)
Don’t know/refused	28 (0.84)	50 (1.32)	16 (0.44)
Student			
Yes	3124 (89.81)	3080 (89.76)	3121 (86.79)
No	298 (9.42)	239 (9.95)	380 (13.09)
Don’t know/refused	22 (0.77)	8 (0.29)	8 (0.12)
Monthly alcohol use			
No	1462 (44.64)	2011 (63.35)	2700 (76.36)
Yes	1934 (53.93)	1254 (34.84)	740 (21.55)
Don’t know/refused	48 (1.43)	62 (1.81)	69 (2.10)
Past-30-day marijuana use			
Yes	298 (10.16)	416 (12.94)	445 (14.46)
No	3088 (88.00)	2860 (85.64)	2994 (83.05)
Don’t know/refused	58 (1.83)	51 (1.42)	70 (2.49)
Computers in household			
0-2	684 (21.58)	640 (22.18)	960 (30.01)
≥3	2701 (76.73)	2644 (76.50)	2524 (69.20)
DK/refused	59 (1.70)	43 (1.31)	25 (0.78)
Bathrooms in household			
0-1	1753 (53.19)	800 (27.73)	728 (20.69)
≥2	1671 (46.20)	2503 (71.45)	2771 (79.01)
DK/refused	20 (0.61)	24 (0.82)	10 (0.30)
Smoking status			
Never	2000 (61.76)	2307 (77.63)	2317 (58.49)
Former	26 (1.74)	21 (1.63)	23 (1.46)
Experimental	1214 (21.77)	857 (8.89)	1007 (29.24)
Current	204 (14.72)	142 (11.85)	162 (10.80)
Vaping status			
Never	2266 (64.36)	2351 (72.20)	2311 (61.72)
Former	17 (0.96)	12 (0.72)	27 (1.15)
Experimental	1115 (31.83)	905 (24.03)	1084 (32.56)
Current	46 (2.84)	59 (3.04)	87 (4.57)

Table 2. Adjusted associations between youth reporting that their friends smoke and their friends vape (i.e., descriptive norms) and: country, smoking status, vaping status, and all covariates (n=10,280). All data are weighted unless otherwise stated

	Unweighted n (% of full sample)	Friends smoke (vs. otherwise)			Friends vape (vs. otherwise)		
		%	AOR (95% CI)	p	%	AOR (95% CI)	p
Country							
England (ref)	3444 (33.1)	56.2	1.00		51.6	1.00	
Canada	3327 (32.3)	43.2	**0.71 (0.62-0.82)**	**<.001**	50.4	**1.17 (1.02-1.36)**	**.029**
US	3509 (34.6)	40.8	**0.54 (0.47-0.62)**	**<.001**	52.8	1.10 (0.96-1.27)	.162
Smoking status							
Never (ref)	6624 (65.8)	33.2	1.00		40.4	1.00	
Former	70 (1.6)	79.5	**5.25 (2.57-10.72)**	**<.001**	85.1	1.50 (0.68-3.33)	.315
Experimental	3078 (20.2)	63.6	**2.62 (2.29-2.99)**	**<.001**	68.5	**1.27 (1.10-1.45)**	**.001**
Current	508 (12.4)	86.3	**8.10 (5.76-11.4)**	**<.001**	79.2	1.21 (0.89-1.64)	.226
Vaping status							
Never (ref)	6928 (66.0)	35.6	1.00		35.5	1.00	
Former	56 (1.0)	78.8	1.68 (0.86-3.26)	.128	87.4	**8.47 (2.67-26.93)**	**<.001**
Experimental	3104 (29.6)	67.0	**1.53 (1.34-1.76)**	**<.001**	81.4	**6.18 (5.32-7.18)**	**<.001**
Current	192 (3.5)	75.7	1.00 (0.63-1.57)	.996	95.6	**26.54(10.59-66.51)**	**<.001**
Age							
16 (ref)	1751 (20.1)	38.3	1.00		42.6	1.00	
17	2408 (26.8)	42.2	1.06 (0.91-1.25)	.453	47.0	**1.18 (1.01-1.38)**	**.037**
18	3418 (30.2)	48.5	1.14 (0.98-1.33)	.081	55.0	**1.33 (1.14-1.54)**	**<.001**
19	2703 (22.9)	57.0	**1.37 (1.17-1.62)**	**<.001**	60.7	**1.44 (1.21-1.70)**	**<.001**
Sex							
Male (ref)	3964 (53.1)	47.5	1.00		53.0	1.00	
Female	6316 (46.9)	45.8	1.05 (0.95-1.17)	.307	50.1	0.97 (0.87-1.07)	.505
Ethnicity							
White (ref)	6860 (71.2)	47.9	1.00		51.5	1.00	
Other/mixed	3326 (28.0)	43.9	**1.13 (1.01-1.28)**	**.041**	52.3	**1.24 (1.10-1.39)**	**<.001**
Don't know/refused	94 (0.9)	35.0	0.86 (0.50-1.48)	.584	42.6	0.96 (0.55-1.67)	.874
Student							
Yes (ref)	9325 (88.8)	45.6	1.00		50.5	1.00	
No	917 (10.9)	56.7	0.87 (0.71-1.05)	.145	60.6	0.90 (0.73-1.11)	.313
Don't know/refused	38 (0.4)	24.1	**0.18 (0.05-0.69)**	**.013**	54.0	1.02 (0.45-2.30)	.971
Monthly alcohol use							
No (ref)	6173 (61.7)	36.2	1.00		43.9	1.00	
Yes	3928 (36.6)	64.4	**1.76 (1.56-1.98)**	**<.001**	64.4	**1.43 (1.26-1.62)**	**<.001**
Don't know/refused	179 (1.8)	44.7	1.08 (0.71-1.64)	.724	59.8	1.43 (0.91-2.25)	.119
Past-30-day marijuana use							
No (ref)	8942 (85.5)	42.2	1.00		47.1	1.00	
Yes	1159 (12.6)	74.6	**1.41 (1.15-1.73)**	**.001**	79.7	**1.27 (1.01-1.60)**	**.045**
Don't know/refused	179 (1.9)	65.7	1.48 (1.00-2.21)	.051	72.5	1.31 (0.89-1.93)	.168
Computers in household							
0-2 (ref)	2284 (24.7)	50.5	1.00		55.8	1.00	
≥3	7869 (74.1)	45.4	1.04 (0.91-1.18)	.579	50.4	1.01 (0.89-1.15)	.879
Don't know/refused	127 (1.3)	45.1	1.15 (0.70-1.89)	.590	45.0	0.89 (0.55-1.44)	.643
Bathrooms in household							
0-1 (ref)	3281 (33.7)	52.0	1.00		53.9	1.00	
≥2	6945 (65.7)	44.0	0.99 (0.88-1.12)	.929	50.5	0.97 (0.86-1.10)	.614
Don't know/refused	54 (0.6)	40.8	1.06 (0.49-2.32)	.877	46.5	1.28 (0.61-2.68)	.506

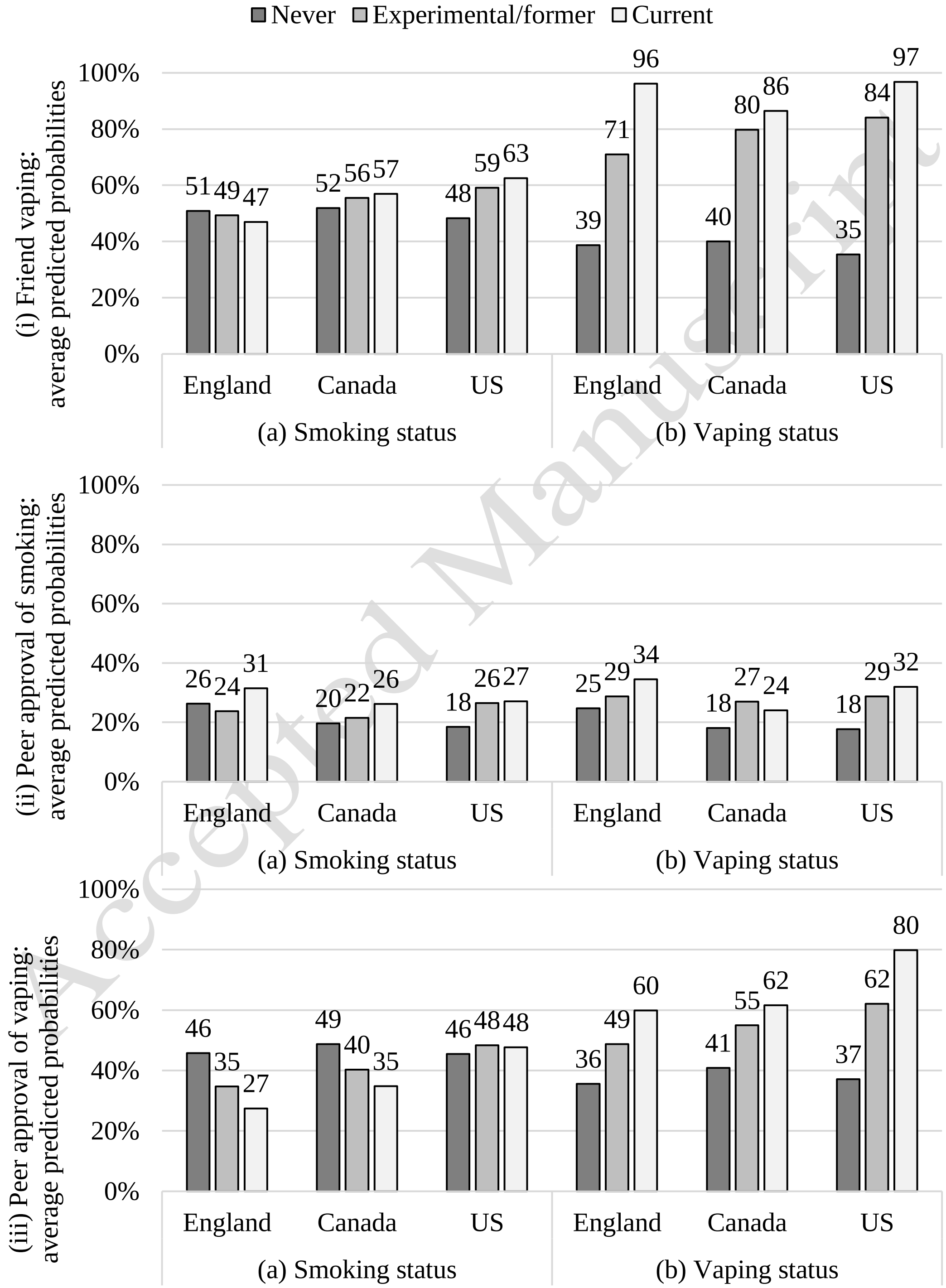
AOR=Adjusted Odds Ratio. 95% CI=95% Confidence Interval.

Table 3. Adjusted associations between youth perceiving that their peers approve of smoking and their peers approve of vaping (i.e., injunctive norms) and: country, smoking status, vaping status, and all covariates (n=10,280). All data are weighted unless otherwise stated

	Unweighted n (% of full sample)	Peers approve of smoking (vs. not approve)			Peers approve of vaping (vs. not approve)		
		%	AOR (95% CI)	p	%	AOR (95% CI)	p
Country							
England (ref)	3444 (33.1)	25.4	1.00		40.2	1.00	
Canada	3327 (32.3)	21.1	**0.74 (0.63-0.87)**	**<.001**	45.6	**1.23 (1.08-1.41)**	**.002**
US	3509 (34.6)	22.7	**0.78 (0.67-0.91)**	**.002**	47.1	**1.30 (1.14-1.48)**	**<.001**
Smoking status							
Never (ref)	6624 (65.8)	19.7	1.00		42.7	1.00	
Former	70 (1.6)	28.7	1.14 (0.61-2.14)	.683	55.1	0.81 (0.47-1.40)	.457
Experimental	3078 (20.2)	27.3	**1.20 (1.03-1.39)**	**.019**	47.4	**0.82 (0.72-0.93)**	**.003**
Current	508 (12.4)	33.8	**1.44 (1.09-1.90)**	**.011**	46.5	**0.62 (0.48-0.79)**	**<.001**
Vaping status							
Never (ref)	6928 (66.0)	19.1	1.00		39.3	1.00	
Former	56 (1.0)	34.4	1.84 (0.91-3.72)	.088	47.1	**1.98 (1.02-3.83)**	**.044**
Experimental	3104 (29.6)	30.4	**1.57 (1.34-1.83)**	**<.001**	53.2	**2.08 (1.82-2.37)**	**<.001**
Current	192 (3.5)	34.6	**1.81 (1.16-2.81)**	**.008**	63.8	**3.86 (2.53-5.88)**	**<.001**
Age							
16 (ref)	1751 (20.1)	22.9	1.00		41.7	1.00	
17	2408 (26.8)	23.4	0.98 (0.82-1.16)	.784	41.2	0.97 (0.84-1.12)	.685
18	3418 (30.2)	22.4	**0.83 (0.70-0.99)**	**.036**	46.2	1.11 (0.96-1.28)	.152
19	2703 (22.9)	23.9	0.84 (0.70-1.02)	.074	47.8	1.13 (0.97-1.31)	.131
Sex							
Male (ref)	3964 (53.1)	21.7	1.00		40.9	1.00	
Female	6316 (46.9)	24.7	**1.27 (1.13-1.43)**	**<.001**	48.2	**1.37 (1.24-1.51)**	**<.001**
Ethnicity							
White (ref)	6860 (71.2)	21.2	1.00		42.5	1.00	
Other/mixed	3326 (28.0)	27.9	**1.61 (1.41-1.83)**	**<.001**	49.4	**1.30 (1.16-1.45)**	**<.001**
Don’t know/refused	94 (0.9)	23.2	1.23 (0.66-2.27)	.511	33.6	0.77 (0.45-1.32)	.350
Student							
Yes (ref)	9325 (88.8)	22.5	1.00		44.0	1.00	
No	917 (10.9)	28.2	1.21 (0.98-1.49)	.075	47.6	1.07 (0.89-1.28)	.460
Don’t know/refused	38 (0.4)	29.4	1.15 (0.48-2.77)	.752	33.2	0.74 (0.34-1.62)	.447
Monthly alcohol use							
No (ref)	6173 (61.7)	21.8	1.00		43.8	1.00	
Yes	3928 (36.6)	24.6	0.95 (0.82-1.10)	.493	45.3	0.98 (0.87-1.10)	.712
Don’t know/refused	179 (1.8)	36.1	**1.75 (1.18-2.59)**	**.005**	40.0	0.80 (0.54-1.19)	.276
Past-30-day marijuana use							
No (ref)	8942 (85.5)	21.6	1.00		43.0	1.00	
Yes	1159 (12.6)	32.8	**1.24 (1.00-1.52)**	**.047**	53.0	1.11 (0.92-1.34)	.274
Don’t know/refused	179 (1.9)	27.4	0.94 (0.59-1.48)	.776	44.9	0.90 (0.59-1.36)	.604
Computers in household							
0-2 (ref)	2284 (24.7)	27.0	1.00		45.5	1.00	
≥3	7869 (74.1)	21.8	**0.85 (0.74-0.98)**	**.026**	44.0	1.00 (0.89-1.14)	.964
Don’t know/refused	127 (1.3)	26.5	1.09 (0.61-1.94)	.766	40.8	1.12 (0.68-1.85)	.662
Bathrooms in household							
0-1 (ref)	3281 (33.7)	25.2	1.00		45.6	1.00	
≥2	6945 (65.7)	22.0	0.98 (0.86-1.13)	.823	43.7	**0.87 (0.78-0.97)**	**.016**
Don’t know/refused	54 (0.6)	25.7	0.92 (0.35-2.42)	.873	34.8	0.74 (0.34-1.61)	.452

AOR=Adjusted Odds Ratio. 95% CI=95% Confidence Interval.

Figure 1. Interactions between country (England, Canada, US) and (a) smoking status (never, experimental/former, current), (b) vaping status (never, experimental/former, current) for (i) friend vaping, (ii) peer approval of smoking, and (iii) peer approval of vaping. Predicted probabilities are weighted and adjusted, n=10,280



Highlights

- England had more pro-smoking but less pro-vaping norms overall
- Canada and US differed on friend smoking only, which was greater in Canada than US
- Country differences cannot easily be explained by prevalence or policies
- Smokers had more pro-smoking norms, vapers had more pro-vaping norms
- There were also some cross-product associations between norms and product use

Author Disclosures

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Contributors

Katherine East led the data analysis and write-up of the manuscript. Sara Hitchman and Ann McNeill provided input on the research questions, survey design, analysis plan, interpretation of results, manuscript write-up, and critically reviewing the manuscript.

James Thrasher provided input on the survey design, analysis plan, interpretation of the results, and critically reviewing the manuscript.

David Hammond was the Principal Investigator of the Youth Tobacco and Vaping Survey used in this study, and provided input on the survey design, analysis plan, interpretation of the results, and critically reviewing the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Conflicts of interest

JFT and DH have served on behalf of governments in response to legal challenges from the tobacco industry. All other authors have no conflicts of interest.

6.3. Discussion in relation to this thesis

In my publication above I provided the first assessment of the associations between smoking and vaping norms and (i) country, (ii) smoking status, and (iii) vaping status, using cross-sectional data from youth age 16-19 in England, Canada, and the US [3]. I found that friend smoking and perceived peer approval of smoking were most commonly reported among English youth, while friend vaping and perceived peer approval of vaping were most commonly reported among Canadian youth [3]. Both smoking norms were more positive among smokers, while both vaping norms were more positive among vapers [3]. I also found associations between norms towards one product and use of the other [3].

As mentioned in my publication above, country differences in social norms towards smoking generally did not correspond with strength of tobacco control policies in each country [3]. England's higher rates of youth smoking prevalence and Canada's long history of comprehensive tobacco control policies could explain why English youth had more positive norms towards smoking than Canadian youth [3, 129, 227, 255, 256]. However, tobacco control policies and smoking prevalence rates could not easily explain other country differences in smoking norms [3, 129, 227, 255, 256]. Overall, my findings were inconsistent with previous research [113, 120, 134] and theories placing social norms on the pathway between changes in tobacco control policies and smoking prevalence rates [58-62].

Also as mentioned in my publication above, country differences in social norms towards vaping generally did not correspond with vaping policies or vaping prevalence rates in each country [3, 227]. Instead, Canadian youth reported more positive vaping norms than England, despite Canada having the most restrictive vaping policies and lowest rates of youth smoking prevalence [3, 227]. These findings are also inconsistent with previous research I have been involved in assessing country differences in vaping norms among adult smokers [138].

Consistent with my findings from the systematic review and meta-analysis in Chapter 2 and previous research [97, 99], I found that friend smoking, and also perceiving that peers approve of smoking, were most common among youth who had experimented with smoking or were current smokers [3]. Also consistent with previous research [90] and Chapter 2, descriptive norms were more strongly associated with smoking than injunctive norms, such that there was a strong dose-response association between friend smoking and greater smoking behaviour that was not mirrored for perceived peer approval [3].

Consistent with my longitudinal findings among British youth in Chapter 4 [1] and other cross-sectional research [15, 136, 137, 166], I found that friend vaping, and also perceived peer approval of vaping, were more common among youth who were current or experimental vapers [3]. Again, I found a strong dose-response association between greater friend vaping and greater vaping behaviour that was not mirrored for perceived peer approval [3].

I found positive associations between norms towards smoking and youth vaping [3]. Specifically, friend smoking and perceived peer approval of smoking were more common among youth who experiment with vaping than have never vaped, although this was only found in England and the US. These findings are concerning because they suggest that vaping among youth could increase how common and approved of smoking is perceived to be, consistent with claims that vaping could renormalise smoking [15, 50, 55, 56]. However, the cross-sectional nature of this data cannot determine the direction of associations, and my longitudinal findings from Chapter 4 suggest that perceiving smoking to be approved of by society was *protective* against vaping initiation [1], contrary to renormalisation concerns [35, 48, 51-56].

I also found associations between norms towards vaping and youth smoking, although the direction of associations was mixed. Friend vaping was more common among youth who experiment with smoking, although this was only found in the US. This finding is again concerning because it is consistent with the notion that vaping could renormalise and increase youth smoking in the US [35, 48, 51-56]. However, it is again inconsistent with my longitudinal findings from Chapter 4, whereby friend vaping was *protective against* smoking initiation among British youth [1]. Moreover, in this Chapter I found that perceiving peer approval of vaping was less common among youth who experiment with smoking or are current smokers in England and Canada [3]. My findings suggest that, at least in England and Canada, perceiving smoking as more common and approved of among friends/peers could be protective against smoking. However, again the direction of associations cannot be determined from this cross-sectional data.

The discrepancies between some of my findings in this Chapter (Chapter 6) [3] and Chapter 4 [1] could be because of several reasons. First, Chapter 4 involved the analysis of longitudinal data [1] while the data used in this Chapter were cross-sectional [3]. Cross-sectional associations could emerge because norms predict behaviour, or because behaviour predicts norms [97, 98]; the longitudinal results in Chapter 4 provide more evidence in support of the former [1]. Second, this Chapter used data from England, Canada, and the US [3], while Chapter 4 used data from Great Britain only [1]. The associations between norms and behaviour were found to vary by country in this Chapter [3] and the systematic review and meta-analysis in Chapter 2. Third, this Chapter used data from 16-19-year-olds [3], while Chapter 4 used data from 11-18 year olds [1] and the associations between norms and behaviour could differ across age groups. Fourth, the analyses used in this Chapter did not adjust for a range of social norms variables towards both products [3], whereas those used for Chapter 4 did [1]. It is likely that youth who experiment with vaping also experiment with smoking or used to smoke. Thus, the apparent association between friend vaping and smoking experimentation could in fact be attributable to an association between friend smoking and smoking experimentation. However, this cannot be determined without additional analyses which go beyond the scope of this Chapter.

6.3.1. Conclusion

My findings from this Chapter (Chapter 6) suggest that smoking and vaping norms among youth do not always correspond with policies and prevalence rates, contrary to theorised [3]. Consistent with previous findings and research, friend smoking was positively associated with smoking, and friend vaping was positively associated with vaping [3]. Perceived peer approval of smoking and vaping were also positively associated with smoking and vaping, respectively, but to a lesser extent than friend smoking and friend vaping. There was also evidence of associations between norms towards one product and use of the other.

However, the direction of associations was mixed, found to differ across countries, and were inconsistent with my findings from Chapter 4 [1]. Overall, my findings from this Chapter preclude any firm conclusions regarding the potential of vaping to renormalise, or denormalise, smoking among youth [3]. However, they suggest that effects in either direction are possible [3].

6.4. Impact and dissemination

My publication above was part of the ITC Youth Tobacco and E-Cigarette Survey and the wider ITC Project [3]. My publication therefore forms part of a larger body of evidence evaluating the factors that predict vaping initiation among youth, and evaluating the impact of tobacco and nicotine policies on public health [60, 227]. I presented my publication as a poster at the Society for Research on Nicotine and Tobacco (SRNT) Europe 2018 Annual Meeting in Munich, Germany (poster available online at [12]).

CHAPTER 7

Smoking and Vaping Norms Among Adult Smokers Across Europe

7.1. Preface

Smoking and vaping prevalence rates and strength of tobacco control policies also vary across Europe [129, 257, 258]. In Chapter 7 I extended my findings from Chapter 6 [3] to assess whether (i) smoking norms correspond with smoking prevalence, (ii) vaping norms corresponded with vaping prevalence, and (iii) smoking norms corresponded with tobacco control policy strength, among adult smokers in seven European countries. I did not assess associations between vaping norms and vaping policies because vaping policies were largely similar across the seven European countries under the European Union (EU) 2014 Tobacco Products Directive (TPD) [53].

These objectives relate to *Aims 6-7* of my thesis: To assess, among adult smokers (and youth), whether smoking norms correspond with tobacco control policies and smoking prevalence rates *(Aim 6)* and vaping norms correspond with vaping policies and vaping prevalence rates *(Aim 7)*.

In Section 7.2 below I present my fourth peer-reviewed publication [4]:

East, K., Hitchman, S.C., McDermott, M., McNeill, A., Herbeć, A., Tountas, Y., Bécuwe, N., Demjén, T., Fu, M., Fernández, E., Mons, U., Trofor, A.C., Zatoński, W. Fong, G.T., & Vardavas, C., on behalf of the EUREST-PLUS consortium (2019). Social Norms Towards Smoking and Electronic Cigarettes Among Adult Smokers in Seven European Countries: Findings from the EUREST-PLUS ITC Europe Surveys. Tobacco Induced Diseases, 16(2). doi: 10.18332/tid/104417.

In my publication I focussed on objectives (i) and (ii) above [4]. I have provided a discussion focussing on (iii) and contextualising the findings into this thesis below my publication, in Section 7.3. I have also included a summary of the impact and dissemination of this work, in Section 7.4.

7.1.1. Declaration of roles

This publication [4] was part of the international European Regulatory Science on Tobacco: Policy Implementation to Reduce Lung Disease (EUREST-PLUS) Project [59, 229, 230]. I developed this publication in collaboration with Dr Sara C Hitchman, Professor Ann McNeill, and Dr Máirtín McDermott (King's College London), Dr Aleksandra Herbeć and Professor Witold A Zatoński (Health Promotion Foundation, Poland), Professor Yannis Tountas (National and Kapodistrian University of Athens, Greece), Nicolas Bécuwe (Kantar Public, Belgium), Tibor Demjén (Smoking or Health Hungarian Foundation, Hungary), Dr Marcela Fu and Professor Esteve Fernández (Catalan Institute of Oncology, Spain), Dr Ute Mons (German Cancer Research Center, Germany), Dr Antigona C Trofor (Aer Pur Romania), Professor Geoffrey T Fong (University of Waterloo, Canada), and Dr Constantine I Vardavas (University of Crete, Greece).

CIV was the Principal Investigator of the EUREST-PLUS project. CIV, NB, TD, EF, AM, SCH, UM, TY, ACT, WAZ and GTF designed the surveys with national agencies Kantar Public (Belgium, Spain, Hungary, Poland), Metron Analysis (Greece), Foerster and Thelen (Germany), and The University of Waterloo's Survey Research Centre and Ipsos MORI. The national agencies, The University of Waterloo's Survey Research Centre and Ipsos MORI were responsible for sample recruitment and maintenance. All authors SCH, MM, AM, AH, YT, NB, TD, MF, EF, UM, ACT, WAZ, GTF, and CIV provided input on the measures; specifically, I provided input on the smoking and vaping norms measures, which were informed by my previous work [15]. I led the write-up of this publication [4], formulated the research questions, and analysed the data, with input from SCH and AM. All co-authors reviewed and provided input on drafts of this publication [4].

7.1.2. Selection of social norms measures

In this publication [4] I used data from the 2016 International Tobacco Control Policy Evaluation (ITC) Project Europe Surveys. I selected three measures of smoking norms, one measure of opinion of smoking*, and three measures of vaping norms for use in this publication [4]: friend smoking, perceived approval of smoking among people important to you, perceived public approval of smoking, disagreeing that smokers are marginalised*, friend vaping, seeing vaping in public, and perceived public approval of vaping (see Table 3.1).

I selected these eight measures because they covered a range of social groups and covered both descriptive and injunctive norms. Some other smoking and vaping norms measures were included in the ITC Europe Surveys but varied in wording across countries and so were unsuitable to be combined for analyses. Perceiving that smokers are marginalised was selected to complement the social norms measures and because it was consistently measured across countries. The inclusion and wording of all social norms measures in the ITC Europe Surveys were also based on discussions with co-authors and the ITC Europe Survey teams. The wording of some social norms measures in this Chapter therefore differed from other Chapters in this thesis.

7.2. Publication

Research Paper
Tobacco Induced Diseases

Social norms towards smoking and electronic cigarettes among adult smokers in seven European Countries: Findings from the EUREST-PLUS ITC Europe Surveys

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ABSTRACT

INTRODUCTION This study explores whether current smokers' social norms towards smoking and electronic cigarettes (e-cigarettes) vary across seven European countries alongside smoking and e-cigarette prevalence rates. At the time of surveying, England had the lowest current smoking prevalence and Greece the highest. Hungary, Romania and Spain had the lowest prevalence of any e-cigarette use and England the highest.

METHODS Respondents were adult (≥18 years) current smokers from the 2016 EUREST-PLUS ITC (Romania, Spain, Hungary, Poland, Greece, Germany) and ITC 4CV England Surveys (N=7779). Using logistic regression, associations between country and (a) smoking norms and (b) e-cigarette norms were assessed, adjusting for age, sex, income, education, smoking status, heaviness of smoking, and e-cigarette status.

RESULTS Compared with England, smoking norms were higher in all countries: reporting that at least three of five closest friends smoke (19% vs 65–84% [AOR=6.9–24.0; Hungary–Greece]), perceiving that people important to them approve of smoking (8% vs 14–57% [1.9–51.1; Spain–Hungary]), perceiving that the public approves of smoking (5% vs 6–37% [1.7–15.8; Spain–Hungary]), disagreeing that smokers are marginalised (9% vs 16–50% [2.3–12.3; Poland–Greece]) except in Hungary. Compared with England: reporting that at least one of five closest friends uses e-cigarettes was higher in Poland (28% vs 36% [2.7]) but lower in Spain and Romania (28% vs 6–14% [0.3–0.6]), perceiving that the public approves of e-cigarettes was higher in Poland, Hungary and Greece (32% vs 36–40% [1.5–1.6]) but lower in Spain and Romania in unadjusted analyses only (32% vs 24–26%), reporting seeing e-cigarette use in public at least some days was lower in all countries (81% vs 12–55% [0.1–0.4]; Spain–Greece).

CONCLUSIONS Smokers from England had the least pro-smoking norms. Smokers from Spain had the least pro-e-cigarette norms. Friend smoking and disagreeing that smokers are marginalised broadly aligned with country-level current smoking rates. Seeing e-cigarette use in public broadly aligned with country-level any e-cigarette use. Generally, no other norms aligned with product prevalence.

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Research Paper
Tobacco Induced Diseases

INTRODUCTION

Tobacco smoking is the leading cause of preventable morbidity and mortality worldwide[1,2]. In the European Union (EU), just over a quarter of adults (26%) reported currently smoking tobacco in 2017[3]. However, the nicotine market has changed since the relatively recent introduction of electronic cigarettes (e-cigarettes)[4], and there has been a rapid increase in their awareness and use in some countries[5-7]. Both combustible tobacco cigarettes and most e-cigarette liquids contain nicotine, the addictive component of smoking. While not entirely absolved from health risks, some reports suggest that e-cigarette use is less harmful than tobacco smoking to both users and people around them, since e-cigarettes do not contain tobacco and do not involve combustion[8-10]. In 2017, 2% of the EU population reported current e-cigarette use[3].

Social norms towards smoking are often identified as important sources of influence for smoking initiation[11-13], intention to quit smoking[14-16], and smoking cessation[14-16]. In the smoking literature, social norms are commonly defined as perceived approval of smoking by friends, family, those important to them, and society (i.e. injunctive norms)[11,12,14,17], but can also include indicators of perceived visibility, such as self-reported friend smoking and perceptions of how common smoking is (i.e. descriptive norms)[13,18,19]. E-cigarettes, by comparison, are a relatively new product and there is less research on the social norms surrounding them. There have been some debated concerns expressed in the literature[20-22] and the EU Tobacco Products Directive (TPD) 2014 report[23] that e-cigarettes might ‘renormalise’ smoking and promote tobacco consumption. Given this, research evaluating social norms towards both e-cigarettes and smoking is of particular importance in the EU.

It is possible that individuals from countries with higher smoking prevalence rates have more pro-smoking social norms. A study among adult smokers in 2002–2003 found that perceived social denormalisation of smoking was lowest in the UK compared with Canada, Australia, and the US[14]; during these years the UK had the highest prevalence of any tobacco smoking of these four countries[24]. Further, a study assessing the 27 countries of the EU found that attitudes towards smoking restrictions were more favourable among those countries with more advanced tobacco control policies and lower smoking prevalence rates[25]. Less is known about country differences in social norms towards e-cigarettes.

Figure 1 shows the prevalence of smoking and e-cigarette use in the seven EU countries of the EUREST-PLUS and International Tobacco Control Policy Evaluation (ITC) Project: Romania, Spain, Hungary, Poland, Greece, Germany, and England. An overview of each country’s tobacco and e-cigarette policy environment is also provided (Figure 1). Of these countries, England had the lowest rates of current smoking (17%) in 2017[3], accompanied by a strong history of tobacco control policies (Figure 1). Germany, Romania, Spain, Hungary, and Poland have similar rates of current smoking (25–30%), while Greece has the highest current smoking rate (37%) (Figure 1). E-cigarette prevalence rates and policies also differ across these countries (Figure 1); however, *any*, rather than current, e-cigarette use is described, due to low rates of current e-cigarette use and few country differences[3]. England has the highest rates of any e-cigarette use (21%), while Poland, Greece, and Germany (14–15%), and Romania, Spain, and Hungary (10–12%) have similar rates (Figure 1).

The objective of this study was to explore whether social norms towards smoking and e-cigarettes among adult smokers align with smoking and e-cigarette prevalence rates in the seven EU countries of the EUREST-PLUS and ITC Project. It was hypothesised that: 1) social norms will be more pro-smoking among smokers from countries with higher rates of current smoking (i.e. Greece), compared to those from countries with lower rates of current smoking (i.e. England); and 2) social norms will be more pro-e-cigarette among smokers from countries with higher rates of any e-cigarette use (i.e. England), compared to those from countries with lower rates of any e-cigarette use (i.e. Hungary, Romania, Spain).

METHODS

Pre-registration

The hypotheses, methods and analysis plan were pre-registered on the Open Science Framework on 10 May 2018[26]. Hypothesis 2 was changed slightly due to a mistake in the analysis pre-registration, whereby Romania was initially missed.

Sample

This study is part of the European Regulatory Science

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Figure 1. Key tobacco and e-cigarette policies in England, Romania, Spain, Hungary, Poland, Greece, and Germany[3,23,27,28]

	Smoke-free (SF) legislation	Health warnings (HWs) + packaging	Advertising, promotion + sponsorship, including Point of Sale (PoS)	Tax (average retail pack price[1] in 2016)	National campaign 2014-2016?	Year vending machine sales banned	Other tobacco control policies	E-cigarette policies as of 2016	Year ratified FCTC[2]	2016 TCS[3] score	2017 prevalence among adults	
											Current smoking	Any EC
England	2007: Comprehensive, compliance good. Hotel rooms, prisons, + nursing homes excepted.	2009: HWs 40% of back. 2016: Plain packaging.	2003: Partial ban. 2004: PoS regulation. 2005: International sponsorship ban. 2010: Ban TV product placement. 2012-2015: Comprehensive ban, including PoS.	2002: 78%. 2011-2014: Increase by 2% above inflation. (€9.42)	Yes	2011	2015: Ban smoking in private vehicles with children <18.		2004	81 (UK)	17% (UK)	21% (UK)
Romania	2008: Partial, allowances for designated smoking areas. 2016: Comprehensive.	2008: HWs ≥30% of pack, characteristics + position specified, banned packs <20.	2008: Comprehensive ban except PoS.	2014: 75% (€3.28)	Yes	2008		€0.11 tax per ml.	2006	56	28%	11%
Spain	2006: Comprehensive except designated smoking rooms.	2002: HWs ≥30% front, 10% sides, rotated, constituents listed. 2006: Banned packs <20. 2010. Pictorial HWs.	2003: Comprehensive ban. 2006: Smoking + product placement in media banned. No PoS ban.	2014: 78% (€4.44)	No	Not banned	2003: Misleading descriptors banned. 2006: Discounts prohibited.	Banned where smoking is banned. Advertisements regulated.	2005	55	28%	12%
Hungary	1999: Comprehensive except designated smoking areas.	1999: HWs 30% front, 40% back, 10% sides, rotated.	1995: Comprehensive advertising ban. 2008: Promotion + sponsorship banned, except PoS.	2014: 77% (€3.38)	No	2006	1999: Tobacco sold separate from unrelated products. 2011: Misleading descriptors banned. 2014: Sale only in National Tobacco Shops.	€0.21 tax per ml. Advertising banned. Banned where smoking is banned. Flavours prohibited.	2004	53	27%	10%
Poland	2010: Partial, exceptions e.g. drinking/eating establishments with >2 rooms.	2004: HWs on packs + point of sale (PoS).	1996: Comprehensive ban, except PoS.	2014: 80% (€3.13)	Yes	1996	1996: Additives which increase risk of addiction banned.	Advertising ban. Banned where smoking is banned.	2006	50	30%	15%
Greece	2009: Comprehensive, compliance problematic.		2005: Comprehensive advertising ban. 2008: Banned sale and advertising in health and educational facilities. No PoS ban.	2014: 80% (€3.71)	No	2009	2008: Prohibited manufacture of items resembling tobacco products.	Banned wherever smoking is banned.	2006	40	37%	15%
Germany	2007: State-level. 2008: All states SF restaurants, bars + pubs, with exceptions. 2010 onwards: Comprehensive in 3 of 16 states.	2002: HWs ≥30% of pack, another HW ≥40% of another surface. One of two HWs required.	2003: Advertising + sponsorship banned. 2010: Promotion banned. 2016: Only EU country allowing advertising on billboards. No PoS ban.	2014: 73% (€5.34)	Yes	Not banned	2002: Misleading descriptors banned.		2004	37	25%	14%
ALL (EU TPD[4])		2016: HWs ≥65% front and back, text + picture + cessation info, rotated per annum, restricted pack size.					2016: Characterising flavours and misleading descriptors banned, internet sales banned.	2016: 20mg/mL nicotine limit, HWs 30% of front & back, comprehensive advertising, promotion + sponsorship ban.				

1 Average retail pack price for most popular brand in 2016. 2 FCTC: Framework Convention on Tobacco Control. 3 TCS: Tobacco Control Scale; higher scores indicate stronger implementation of tobacco control policies. 4 EU TPD: European Union Tobacco Products Directive; however there was a 1 year implementation period for these policies, and not all were in place for all countries at the time of surveying.

on Tobacco: Policy Implementation to Reduce Lung Disease (EUREST-PLUS) Project[29,30]. Data were drawn from Wave 1 of the ITC Six European Country (6E1) Survey (Romania, Spain, Hungary, Poland, Greece, Germany; approximately n=1000 per country) and the England arm of the Wave 1 ITC Four Country Smoking and Vaping (4CV1) Survey (n=3536). These surveys were designed to be nationally representative of current cigarette smokers aged ≥18 years in each country. Survey weights were incorporated to enhance representativeness, and were calculated using information on gender, age, urbanization, and region from national benchmark surveys; further details are provided elsewhere[29-32].

Data from the ITC 6E1 Survey were collected between 18 June and 12 September 2016. Briefly, data were collected via face-to-face household interviews using tablets (CAPI) and respondents were sampled using a probability approach. Approximately 100 area clusters were sampled in each country, with the aim of obtaining 10 adult smokers per cluster. Within each cluster, household addresses were sampled using a random walk design, and where possible one randomly selected male smoker and one randomly selected female smoker were chosen for interview. Monetary incentives were provided to respondents based on each survey agency's remuneration structure (Germany, Hungary, Poland €10; Romania €7; Greece €5; Spain €3). Further details are available elsewhere[29-31].

Data from the ITC 4CV1 England Survey were collected between 7 July and 16 November 2016. Briefly, data were collected online and the majority of respondents were sampled using a non-probability

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approach. The sample comprised the following cohorts: 1) recontact smokers and quitters living in England who participated in Wave 10 of the earlier 4 Country (4C) Project in the UK; 2) newly recruited current smokers and recent quitters (quit in past 24 months) from a commercial online panel; and 3) newly recruited current e-cigarette users (use at least weekly) from a commercial online panel. In sampling, quotas obtained from national survey data for region crossed with male/female were applied to 2) and 3). Respondents were recruited via random-digit-dialling (RDD) sampling frames, or web-based or address-based panels, or a combination of these frames. Incentives were provided to respondents either in the form of a £16 e-gift card or survey panellist points worth £16–£20. Further details are available elsewhere[32]. Only data from adult current cigarette smokers were used for this study.

Measures

Social norms (outcomes)

The wording of some measures differed between countries. Where wording differed, both measures from the English-translated European Country Surveys[33], and the England arm of the 4CV1 Survey[34] are listed separately below. For all social-norms measures, 'Refused' and 'Don't know' responses were coded as missing and multiple imputation was used (see Analyses section).

(i) At least three of five closest friends smoke. European Survey: 'Of the five closest friends or acquaintances that you spend time with on a regular basis... How many of them smoke ordinary cigarettes? 0–5'. England Survey: 'How many friends or acquaintances do you spend time with on a regular basis? 0–5, More than 5', followed by 'Of (these 1–5/the 5 closest) friends or acquaintances that you spend time with on a regular basis, how many of them smoke ordinary cigarettes? 0–5'. Responses were dichotomised as less than three (0–2) vs at least three (3–5).

(ii) People important to you approve of smoking. 'What do people who are important to you think about you smoking cigarettes? (a) All or nearly all approve, (b) Most approve, (c) About half approve and half disapprove, (d) Most disapprove, (e) All or nearly all disapprove'. Responses were dichotomised as 'approve' (a-b) or 'not approve' (c-e).

(iii) The public approves of smoking. 'What do you think the general public's attitude is towards smoking cigarettes? (a) Strongly approves, (b) Somewhat approves, (c) Neither approves nor disapproves, (d) Somewhat disapproves, (e) Strongly disapproves'. Responses were dichotomised as 'approve' (a-b) or 'not approve' (c-e).

(iv) People who smoke are marginalised. 'People who smoke are more and more marginalized. (a) Strongly agree, (b) Agree, (c) Neither agree nor disagree, (d) Disagree, (e) Strongly disagree'. Responses were dichotomised as 'disagree' (d-e) or 'not disagree' (a-c).

(v) At least one of five closest friends use e-cigarettes. European Survey: 'Of the five closest friends or acquaintances that you spend time with on a regular basis... How many of them use e-cigarettes or vaping devices? 0–5'. England Survey: 'How many friends or acquaintances do you spend time with on a regular basis? 0–5, More than 5', followed by 'Of [these 1–5 / the 5 closest] friends or acquaintances that you spend time with on a regular basis, how many of them use e-cigarettes / vaping devices? 0–5'. Responses were dichotomised as none (0) or at least one (1–5), due to the low percentage of respondents who had friends using e-cigarettes.

(vi) The public approves of e-cigarettes. European Survey: 'What do you think the general public's attitude is towards using e-cigarettes or vaping devices?' England Survey: 'What do you think the general public's attitude is towards vaping/ using e-cigarettes? (a) Strongly approves, (b) Somewhat approves, (c) Neither approves nor disapproves, (d) Somewhat disapproves, (e) Strongly disapproves'. Responses were dichotomised as 'approve' (a-b) or 'not approve' (c-e).

(vii) Seeing e-cigarette use in public. European Survey: 'In the last 30 days, how often have you seen anyone using an e-cigarette or vaping device in public?' England Survey: 'In the last 30 days, how often, if at all, have you seen anyone vaping (using e-cigarettes) in public? (a) Every day, (b) Most days, (c) Some days, (d) Rarely, (e) Not at all'. Responses were dichotomised as 'at least some days' (a-c), or 'rarely/not at all' (d-e).

Country

Country was the key correlate: England, Romania, Spain, Hungary, Poland, Greece, Germany.

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Covariates
Age: 18–24, 25–39, 40–54, ≥55.
Sex: male, female.
Household income: low, moderate, high, not reported. For England (£) based on annual income: low ≤15000, moderate 15001–30000, high >30000. For the other countries based on monthly income. Germany, Greece and Spain (€): low <1750, moderate 1750–3000, high >3000. For Hungary (Ft): low ≤150000, moderate 150001–250000, high >250000. For Poland (zł): low ≤2000, moderate 2001–4000, high >4000. For Romania (lei): low ≤1000, moderate 1001–2500, high >2500.
Education: low, moderate, high.
This variable was defined using the International Standard Classification of Education (ISCED), which was, in turn, categorised into low (pre-primary, primary, lower secondary), moderate (upper secondary, post-secondary non-tertiary, short-cycle tertiary), and high (bachelor or equivalent, master or equivalent, doctoral or equivalent).
Smoking status: daily, non-daily.
E-cigarette status: current user (use daily, weekly, or occasionally), current non-user.
Heaviness of Smoking Index (HSI): 0–6.
The HSI consists of two items: time to first cigarette after waking and number of cigarettes per day[35]. Responses to each item were allocated a score between 0 and 3, and these scores were summed, such that higher values indicate greater heaviness of smoking.

Analyses

Analyses were conducted using Stata v15[36]. First, the percentages of each social-norms outcome (i–vii) were calculated overall and per country. Second, seven unadjusted and adjusted logistic regression models were used to assess associations between country and each social-norms outcome (i–vii). Adjusted models included all covariates listed above. Stata's svy command was used for all analyses to account for complex samples design, incorporating survey weights and strata. All frequencies (n) use unweighted, unstratified, 'raw' data; all percentages (%) use weighted, stratified data.

Missing data
Of the initial 9547 respondents, those who had never heard of e-cigarettes (n=1757) or selected 'Don't know' (n=11) when asked about their e-cigarette status were excluded listwise, leaving 7779 respondents. Missing data were not Missing Completely at Random (MCAR), as country, age, sex, income, education, HSI and e-cigarette use were all associated with missingness. Multiple imputation was therefore used on the remaining sample (n=7779) under the Missing at Random (MAR) assumption for the following 'Don't know' and 'Refused' responses: friend smoking (n=721 [9.3%] observations imputed), people important to you approve of smoking (n=415 [5.3%]), public approve of smoking (n=222 [2.9%]), people who smoke are marginalised (n=288 [3.7%]), friend e-cigarette use (n=773 [9.9%]), public approve of e-cigarettes (n=969 [12.5%]), seeing e-cigarette use in public (n=211 [2.7%]), education (n=90 [1.2%]). Multiple imputation was also used on HSI (n=609 [7.8%] observations imputed); this deviated from the pre-registration[26] due to unanticipated missing values on HSI.

Missing values were imputed using chained equations, and one model was used specifying imputation via logistic regression for all social-norms measures, linear regression for HSI, and ordinal logistic regression for education. Country, age, sex, income, smoking status, and e-cigarette status were included as predictors in the model, and survey weights and strata were incorporated. Forty imputations were used because 31% of respondents had missing data (i.e. responded 'Don't know' or 'Refused') on at least one variable included in this study[26]. More respondents from the England sample, who completed the survey online, had missing data on at least one variable (43%) than those from the European samples who completed the survey face-to-face (21%). Sensitivity analyses found no differences in the prevalence of any social-norms measure ±1%, in the direction of any odds ratios, or in the significance indicated by p-values at the 0.05 cut-off, when using multiple imputation vs complete case analysis.

RESULTS

Sample characteristics

Most respondents were aged 40–54 years, male, had moderate income except Germany (most low or moderate) and England (most high), had moderate education except Germany and Hungary (both majority low education), and were daily smokers but not current e-cigarette users (Table 1).

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Table 1. Sample characteristics by country, all % (n) except Heaviness of Smoking Index (HSI), which is mean (SD)

	England (n=3518)	Romania (n=679)	Spain (n=851)	Hungary (n=681)	Poland (n=677)	Greece (n=737)	Germany (n=636)	Total (n=7779)
Age								
18–24	16.7 (798)	15.3 (82)	12.9 (106)	9.7 (41)	7.4 (48)	9.6 (51)	9.7 (64)	15.3 (1190)
25–39	32.3 (864)	39.1 (210)	29.6 (266)	35.8 (202)	36.1 (249)	30.8 (209)	24.3 (173)	27.9 (2173)
40–54	26.4 (936)	30.5 (217)	39.7 (287)	33.4 (242)	30.2 (189)	34.5 (285)	37.3 (217)	30.5 (2373)
≥55	24.7 (920)	15.1 (170)	17.8 (192)	21.2 (196)	26.3 (191)	25.0 (192)	28.7 (182)	26.3 (2043)
Female	45.9 (1573)	41.0 (272)	43.5 (394)	40.4 (324)	44.6 (366)	47.0 (344)	38.7 (313)	46.1 (3586)
Income								
Low	22.4 (771)	15.4 (129)	25.5 (225)	15.4 (117)	13.2 (106)	16.5 (117)	29.8 (191)	21.3 (1656)
Moderate	29.8 (1024)	44.1 (311)	29.7 (241)	27.8 (194)	33.7 (233)	56.8 (398)	29.3 (200)	33.4 (2601)
High	38.4 (1435)	32.9 (182)	6.4 (63)	25.6 (165)	17.7 (112)	10.4 (83)	25.5 (16)	28.4 (2205)
Not reported	9.4 (288)	7.6 (57)	38.4 (322)	31.2 (205)	35.5 (226)	16.4 (139)	15.4 (80)	16.9 (1317)
Education[a]								
Low	20.2 (1002)	23.5 (160)	43.3 (342)	61.5 (394)	12.6 (89)	28.3 (201)	50.3 (323)	32.5 (2511)
Moderate	66.2 (1399)	64.4 (436)	48.3 (432)	31.6 (234)	75.2 (492)	49.9 (368)	40.8 (259)	47.3 (3620)
High	13.7 (1051)	12.1 (75)	8.4 (76)	6.9 (51)	12.2 (86)	21.9 (167)	8.9 (52)	20.2 (1558)
Daily smoker	83.3 (2866)	96.0 (649)	97.6 (827)	98.9 (673)	96.6 (647)	96.6 (711)	90.9 (578)	89.4 (6951)
Current EC user	42.6 (1857)	4.8 (25)	1.3 (10)	3.6 (22)	3.5 (25)	5.4 (41)	9.1 (54)	26.2 (2034)
HSI[a]	2.0 (0.0)	2.9 (0.1)	2.3 (0.1)	2.9 (0.1)	2.6 (0.1)	2.9 (0.1)	2.2 (0.1)	2.3 (0.0)

Percentages (%) are weighted and stratified using multiply imputed data. Frequencies (n) are unweighted and unstratified, without multiple imputation. a Missing data on education (n=90, 1.2%) and HSI (n=609, 7.8%). EC: e-cigarette, HIS: Heaviness of Smoking Index.

Prevalence of each social-norms measure

Overall, 50% of respondents reported that at least three of their five closest friends smoke, 21% perceived that people important to them approve of smoking, 13% perceived that the public approves of smoking, and 19% disagreed that people who smoke are marginalised (Table 2). Overall, 24% of respondents reported that at least one of their five closest friends uses e-cigarettes, 32% perceive that the public approve of e-cigarettes, and 81% reported seeing e-cigarette use in public at least some days (Table 3). There was substantial difference between countries in smoking (Table 2) and e-cigarette (Table 3) norms; these are examined in further detail below.

Hypothesis 1. Social norms towards smoking will be higher in countries with greater current smoking rates

(i) Reporting that at least three of five closest friends smoke

Both unadjusted and adjusted odds of reporting that at least three of five closest friends smoke were highest in Greece, followed by Romania, Spain, Germany, Poland, Hungary, and lowest in England (Table 2). Odds were 6 to 24 times higher in all countries compared with England, and the results also suggest odds were higher in Greece than all countries except Romania, and in Romania than Poland, Hungary, and Germany (Table 2).

(ii) Perceiving that people important to you approve of smoking

Both unadjusted and adjusted odds of perceiving that people important to you approve of smoking were highest in Hungary, followed by Germany, Romania/Poland, Greece, Spain, and lowest in England (Table 2). Odds were 1.8 to 16 times higher in all countries compared with England, and the results also suggest odds were higher in Hungary and Germany than all other countries, and in Poland and Romania than Spain (Table 2).

(iii) Perceiving that the public approves of smoking

Unadjusted odds of perceiving that the public approves of smoking were highest in Hungary, followed by Romania, Germany, Poland, Greece,

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Table 2. Adjusted associations between each social norm towards smoking measures (i)–(iv) and country (N=7779)

	(i) At least three of five closest friends smoke		(ii) People important to you approve of smoking		(iii) The public approves of smoking		(iv) Disagree that people who smoke are marginalised		Current smoking in 2017[a]
	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)	(%)
England (n=3518; ref)									
	19.4	1.00	7.7	1.00	4.9	1.00	9.1	1.00	17
Greece (n=737)									
Unadjusted	83.7	21.38 (16.74–27.32)	18.9	2.77 (2.09–3.69)	16.0	3.73 (2.72–5.12)	50.2	10.11 (8.03–12.73)	37
Adjusted		23.98 (18.25–31.50)		2.84 (2.07–3.91)		5.19 (3.61–7.46)		12.25 (9.39–15.97)	
Poland (n=677)									
Unadjusted	69.8	9.59 (7.67–12.00)	25.9	4.17 (3.20–5.43)	19.1	4.63 (3.42–6.25)	16.5	1.99 (1.48–2.67)	30
Adjusted		10.55 (8.14–13.67)		4.62 (3.40–6.27)		6.82 (4.77–9.75)		2.34 (1.69–3.24)	
Romania (n=679)									
Unadjusted	82.8	20.01 (15.55–25.75)	28.6	4.79 (3.67–6.25)	21.0	5.19 (3.78–7.12)	38.6	6.32 (4.96–8.05)	28
Adjusted		19.00 (14.48–24.94)		4.44 (3.30–5.98)		5.93 (4.11–8.57)		6.90 (5.24–9.09)	
Spain (n=851)									
Unadjusted	73.5	11.53 (9.29–14.33)	13.7	1.90 (1.42–2.54)	5.8	1.20 (0.81–1.76)*	22.9	2.99 (2.36–3.79)	28
Adjusted		11.92 (9.30–15.28)		1.86 (1.34–2.58)		1.69 (1.09–2.60)		3.35 (2.54–4.42)	
Hungary (n=681)									
Unadjusted	64.8	7.63 (6.14–9.48)	57.2	15.98 (12.54–20.36)	36.8	11.37 (8.67–14.89)	10.6	1.19 (0.83–1.71)*	27
Adjusted		6.88 (5.37–8.82)		15.12 (11.42–20.03)		15.80 (11.36-21.99)		1.36 (0.94–1.97)*	
Germany (n=636)									
Unadjusted	70.9	10.13 (8.08–12.70)	54.9	14.51 (11.43–18.43)	20.9	5.16 (3.83–6.94)	20.5	2.59 (1.99–3.37)	25
Adjusted		11.13 (8.69–14.26)		14.87 (11.35–19.48)		6.59 (4.71–9.21)		2.89 (2.18–3.82)	
Total (n=7779)	49.9		21.1		12.9		19.0		

a Data on current smoking rates are from the 2017 Eurobarometer[3]. All data for (i)–(iv) are multiply imputed with survey weights and strata. OR: odds ratio. Adjusted values are adjusted for age, sex, income, education, smoking status, current e-cigarette use and heaviness of smoking index (HSI). *Data not significant at the p≤0.05 cut-off.

Table 3. Adjusted associations between each social norm towards e-cigarette measures (v)–(vii) and country (N=7779)

	(v) At least one of five closest friends uses e-cigarettes		(vi) The public approves of e-cigarettes		(vii) Seeing e-cigarette use in public at least some days		Any e-cigarette use in 2017[a]
	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)	(%)
England (n=3518; ref)							
	28.0	1.00	31.8	1.00	80.5	1.00	21
Greece (n=737)							
Unadjusted	27.1	0.96 (0.77–1.19)*	40.1	1.44 (1.18–1.75)	55.1	0.30 (0.24–0.36)	15
Adjusted		1.64 (1.27–2.11)		1.63 (1.31–2.03)		0.39 (0.31–0.49)	
Poland (n=677)							
Unadjusted	35.6	1.42 (1.14–1.76)	35.9	1.20 (0.97–1.49)*	44.6	0.20 (0.16–0.24)	15
Adjusted		2.69 (2.06–3.50)		1.46 (1.14–1.85)		0.27 (0.22–0.34)	
Romania (n=679)							
Unadjusted	13.5	0.49 (0.30–0.54)	26.1	0.76 (0.59–0.97)	29.5	0.10 (0.08–0.13)	11
Adjusted		0.64 (0.47–0.88)		0.82 (0.63–1.08)*		0.12 (0.09–0.15)	
Spain (n=851)							
Unadjusted	5.7	0.15 (0.11–0.21)	23.7	0.67 (0.53–0.84)	12.7	0.04 (0.03–0.05)	12
Adjusted		0.31 (0.22–0.44)		0.81 (0.62–1.04)*		0.05 (0.04–0.07)	
Hungary (n=681)							
Unadjusted	23.5	0.79 (0.63–1.00)*	37.0	1.26 (1.01–1.57)	16.9	0.05 (0.04–0.07)	10
Adjusted		1.58 (1.21–2.07)		1.49 (1.17–1.89)		0.06 (0.05–0.09)	
Germany (n=636)							
Unadjusted	17.5	0.55 (0.42–0.70)	32.4	1.03 (0.83–1.27)*	28.1	0.09 (0.08–0.12)	14
Adjusted		0.94 (0.72–1.23)*		1.22 (0.97–1.53)*		0.12 (0.10–0.15)	
Total (n=7779)	23.6		32.1		53.1		

a Data on any e-cigarette use are from the 2017 Eurobarometer[3]. All data are multiply imputed with survey weights and strata. OR: odds ratio. Adjusted values are adjusted for age, sex, income, education, smoking status, current e-cigarette use and Heaviness of Smoking Index (HSI). *Data are not significant at the p≤0.05 cut-off.

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Spain, and England, while adjusted odds were highest in Hungary, followed by Poland, Germany, Romania, Greece, Spain, and lowest in England (Table 2). The results suggest odds were lower in England and Spain compared with all other countries, higher in Hungary than all countries, and adjusted odds were also lower in England than Spain (Table 2).

(iv) Disagreeing that people who smoke are marginalised
Both unadjusted and adjusted odds of disagreeing that people who smoke are marginalised were highest in Greece, followed by Romania, Spain, Germany, Poland, Hungary, and lowest in England (Table 2). The results suggest odds were lower in England and Hungary than all other countries, higher in Greece and Romania than all other countries, and adjusted odds were also higher in Greece than Romania (Table 2).

Hypothesis 2. Social norms towards e-cigarettes will be higher in countries with greater rates of any e-cigarette use

(v) Reporting that at least one of five closest friends uses e-cigarettes
Unadjusted odds of reporting that at least one of five closest friends uses e-cigarettes were highest in Poland, followed by England, Greece, Hungary, Germany, Romania, and lowest in Spain (Table 3). Adjusted odds were highest in Poland, followed by Greece, Hungary, England, Germany, Romania, and lowest in Spain (Table 3). The results suggest odds were generally higher in Poland compared with all countries except Greece, higher in Greece than Romania and Germany, higher in England and Hungary than Romania, and lower in Spain than all countries (Table 3).

(vi) Perceiving that the public approves of e-cigarettes
Unadjusted and adjusted odds of perceiving that the public approves of e-cigarettes were highest in Greece, followed by Hungary, Poland, Germany, England, Romania, and lowest in Spain (Table 3). The results suggest odds were generally higher in Greece, Poland and Hungary than England, Romania, and Spain (Table 3).

(vii) Report seeing e-cigarette use in public at least some days
Unadjusted and adjusted odds of reporting seeing e-cigarette use in public at least some days was highest in England, followed by Greece, Poland, Romania, Germany, Hungary, and lowest in Spain (Table 3). Odds were 2.6 to 25 times higher in England compared with all countries, and the results also suggest higher odds in Greece and Poland than all other countries except England, and lower in Spain and Hungary than all other countries (Table 3).

DISCUSSION

Partially consistent with Hypothesis 1, smokers from countries with higher rates of current smoking generally had more pro-smoking social norms on two of four measures: reporting that at least three of their five closest friends smoke, and disagreeing that smokers are marginalised. Except England, generally perceived approval of smoking by those important to you and society did not align with country-level rates of current smoking. Somewhat consistent with Hypothesis 2, smokers from countries with higher rates of any e-cigarette use had more pro-e-cigarette social norms on one of three measures: seeing e-cigarette use in public at least some days. Generally, reporting that at least one of five closest friends uses e-cigarettes and perceiving that the public approves of e-cigarettes did not align with country-level rates of any e-cigarette use. Smokers from England had the least pro-smoking social norms across all four measures and countries, while those from Spain had the least pro-e-cigarette social norms across all three measures and countries.

The finding that England had the least pro-smoking norms across all four measures is unsurprising, given England's substantially lower smoking rate and long history of strong tobacco control policies compared with the other six EU countries in this study (Figure 1). However, England did not have the most pro-e-cigarette social norms on two of three measures, despite its markedly higher country-level rates of any e-cigarette use compared with the other six countries (Figure 1) and some promotion of e-cigarettes as smoking cessation aids by UK public health bodies such as the NHS and Cancer Research UK.

The finding that smokers from Spain had the least pro-e-cigarette social norms across all three measures also warrants further exploration, given that prevalence of any e-cigarette use in Spain was not markedly different from any other country's except

England. Public health authorities in Spain have generally applied precautionary principles towards e-cigarettes, such as banning their use in most public places and workplaces in 2014 (Figure 1). There has also been a delay in the general marketing of e-cigarettes in Spain compared with other countries. It should also be noted that Spanish smokers' low perceived approval of smoking, from those important to them (14%) and the public (6%), is not consistent with the higher smoking prevalence in Spain.

Averaged across all seven countries, perceived public approval of e-cigarettes (32%) was over twice that of perceived public approval of smoking (13%). Moreover, perceived public approval of e-cigarettes was also higher than that of smoking within all countries. This is consistent with reports suggesting e-cigarettes are less harmful to both users and people around them relative to combustible cigarettes[8-10]. It is not possible to compare the other social norms towards smoking with those social norms towards e-cigarettes due to different types of social norms being assessed.

This study is among the first in the EU to assess a variety of both descriptive, more 'visible' measures of adult smokers' social norms towards smoking and e-cigarettes, such as perceived friend use and seeing e-cigarette use in public, in addition to injunctive norms such as perceived approval. The results suggest that the injunctive norms measured here do not align with country-level rates of product use, nor do they generally correspond with the descriptive norms. Given literature highlighting the importance of measures of both the perceived visibility of smoking and perceived approval of smoking[18], future research should aim to consider both normative domains.

There are several potential explanations as to why smokers' perceived approval of smoking by those important to them and that the public did not align with country-level current smoking rates as hypothesised. First, Hypothesis 1 was based on 2017 current smoking prevalence, which fails to consider each country's history of smoking prevalence, and current and previous tobacco control policies. These likely play important roles. Second, the sample was limited to current smokers, who are more likely to be of lower socioeconomic status and lacking the motivation and resources to quit[37]. Such individuals may hold more entrenched or polarised social norms; indeed, current smokers have been found to hold more pro-smoking norms across many self-report measures compared to non-smokers and ex-smokers[19,38]. Therefore, perceived approval of smoking *among current smokers* may be amplified in countries where they are in the minority, although this was not the case in England. Studies assessing smoking, and e-cigarette, social norms among non-smokers and ex-smokers may aid interpretation of these findings.

The finding that social norms towards e-cigarettes, generally, did not align with country-level rates of any e-cigarette use as hypothesised could also be attributed to the sample containing current smokers only. In the EU, e-cigarettes are often used as an aid to smoking cessation[3,39], and some smokers may be encouraged to switch from smoking to e-cigarette use due to the health benefits of switching over continued smoking[7]. Given this, it makes some sense that smokers from countries with historically higher rates of current smoking, such as Greece and Poland, would have greater adjusted odds of friend e-cigarette use and perceived public approval of e-cigarettes. However, this explanation is anecdotal and requires further research. Further, any e-cigarette use is a relatively weak measure of prevalence, yet options for a more refined comparator for Hypothesis 2 were limited, since prevalence of current e-cigarette use was low and similar for each country (<1–5%)[3]. Current and previous e-cigarette policies were also not considered. Other potential explanations pertaining to the unanticipated results for both smoking and e-cigarette social norms include cross-country differences in culture, freedom of speech, liberty and social connectedness, which likely all play a role in the development of social norms[40].

Limitations and strengths

This study is not without limitations. First, the results have limited generalizability since the sample contained only current smokers, who generally hold more pro-smoking norms across many self-report measures[19,38], and have been found to perceive greater public approval of e-cigarettes[19], compared to non-smokers and ex-smokers. Second, the seven EU countries included in this study have all been working to reduce tobacco smoking through strengthening policies over the past decade, and all have some tobacco and e-cigarette policies harmonised under EU legislation. Inclusion of countries at an earlier stage

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of the tobacco epidemic or with considerably less restrictive tobacco control policies may have aided the interpretation of findings. Third, the English sample differed on the wording of some survey items, used online rather than face-to-face methodology, were offered greater monetary incentives, and had more missing data than the other EU country samples. This weakens comparisons made between England and the other countries. Fourth, smokers' understanding of these social-norms measures may differ across the different languages used, and may be subject to cultural biases[41]. Despite these limitations, this study is the first of its kind to compare social norms towards smoking and e-cigarettes in different EU countries, and uses large, nationally representative samples.

CONCLUSIONS

Among current smokers from seven EU countries, those from England had the least pro-smoking social norms, while those from Spain had the least pro-e-cigarette social norms. Reporting that at least three of five closest friends smoke and disagreeing that smokers are marginalised broadly aligned with country-level rates of current smoking, being lowest in England and highest in Greece. Seeing e-cigarette use in public broadly aligned with country-level any e-cigarette use, being lowest in Hungary, Romania and Spain, and highest in England. No other social norms were consistent with smoking and e-cigarette prevalence rates as hypothesised.

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CONFLICTS OF INTEREST
The authors declare that they have no competing interests, financial or otherwise, related to the current work. A Herbec reports grants from Pfizer, outside the submitted work. CI Vardavas reports that he is the Strategic Development Editor of TID and that there are no conflicts of interest with this current work. The rest of the authors have also completed and submitted an ICMJE form for disclosure of potential conflicts of interest.

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AUTHORS' CONTRIBUTIONS
KE led the writing up of this manuscript and performed the data analyses reported, with input from SH and AM. SH, MM, AM and AH provided input on the analysis plan. SH, MM, AM, AH, MF, EF, UM, AT and CV reviewed and commented on manuscript drafts. SH, MM, AM, AH, MF and AT further reviewed and provided input on the manuscript following comments from reviewers. All authors were involved in the EUREST-PLUS project, including the design of the surveys and measures included in this manuscript.

PROVENANCE AND PEER REVIEW
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7.3. Discussion in relation to this thesis

In my publication above I provided the first assessment of whether (i) smoking norms correspond with smoking prevalence rates and (ii) vaping norms correspond with vaping prevalence rates using nationally representative cross-sectional data from adult smokers in seven European countries [4]. My findings suggested that some, but not all, measures of norms corresponded with prevalence rates among adult smokers (Figure 7.1 below, left panels) [4]. Reporting that at least three of five closest friends smoke and disagreeing that smokers are marginalised were more common among smokers from countries with higher smoking prevalence rates [4]. Except in England, smokers' perceived approval of smoking among those important to them and society generally did not correspond with smoking prevalence rates [4]. Considering the vaping norms (Figure 7.2 below), seeing vaping in public at least some days was more common among smokers from countries with higher vaping prevalence rates, although friend vaping and perceiving that the public approves of vaping generally did not correspond with vaping prevalence rates [4].

For the purposes of this thesis, I have also explored whether (iii) smoking norms correspond with tobacco control policy strength across countries. Correlations between smoking norms and each country's strength of tobacco control policies, measured using the 2016 Tobacco Control Scale in Europe [258],[4] are shown in Figure 7.1 below (right panels). The findings in relation to Tobacco Control Scale score broadly mirror those for prevalence rates (Figure 7.1): friend smoking was more common among smokers from countries with weaker tobacco control policies and, except England, smokers' injunctive smoking norms generally did not correspond with Tobacco Control Scale scores. However, unlike my findings

[4] The 2016 Tobacco Control Scale is a measure of tobacco control policies at the country level, including smoke-free policy, spending on public information campaigns, advertising and promotion bans, health warnings, and support to help smokers quit [258]. Scores on the Tobacco Control Scale range from 0 to 100 [258]. The UK has the highest score (81/100) of all European countries.

for smoking prevalence rates, I found that smokers' disagreement that smokers are marginalised did not correspond well with Tobacco Control Scale scores.

Overall, I found that some, but not all norms towards smoking correspond with strength of tobacco control policies and smoking prevalence rates among adult smokers in Europe [4]. Inconsistent with my findings from Chapter 6 [3] but consistent with previous research [120] and theories [58-62], the descriptive norm of friend smoking was more common among smokers from countries with weaker tobacco control policies and greater smoking prevalence [4]. However, consistent with my findings from Chapter 6 [3] but inconsistent with previous research [113, 120, 134] and theories [58-62], except England, smokers' injunctive norms did not correspond with smoking prevalence rates or strength of tobacco control policies. Country differences in smokers' descriptive norms also did not correspond with differences in injunctive norms, consistent with research suggesting that descriptive and injunctive norms are different constructs [89, 90].

My findings suggest that smoking was most denormalised among smokers from England compared to smokers from all other European countries assessed [4]. This is consistent with England's substantially lower smoking rate and much stronger tobacco control policies (see Figure 1 in my publication above [4]) and may suggest that smokers' descriptive and injunctive norms vary in countries where policies and prevalence rates vary substantially. However, as mentioned in my publication above [4], there were several differences between the England survey and the survey administered in the other six European countries, weakening these comparisons. Comparisons made across the six mainland European countries may be more valid, and among these countries there was little correspondence between injunctive smoking norms and tobacco control policies and smoking prevalence rates.

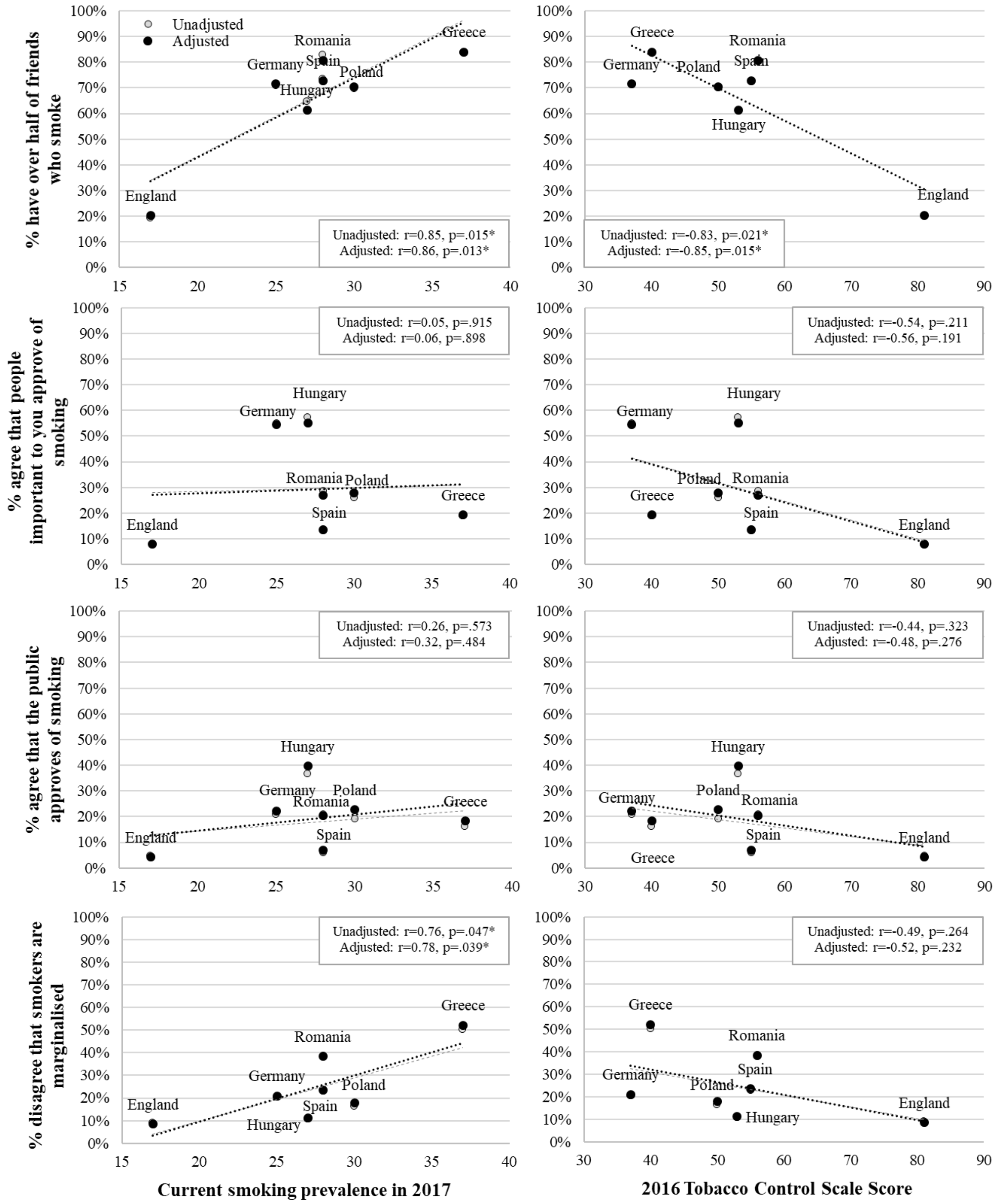
Consistent with my findings from Chapter 6 [3] but inconsistent with previous research [138], I found that the descriptive norm of friend vaping and the injunctive norm of perceiving that the public approves of vaping generally did not correspond with vaping prevalence rates among smokers (Figure 7.2 below). However, consistent with previous research [138], I found that the descriptive vaping norm of seeing vaping in public at least some days was more common among adult smokers from countries with higher vaping prevalence rates (Figure 7.2 below). These findings suggest that some, but not all, vaping norms correspond with vaping prevalence rates among adult smokers. Correlations between vaping norms and strength of vaping policies were not explored because of the similarities in vaping policies across Europe [53] and the lack of a validated scale for vaping policies in Europe.

It is important to mention that only seven countries were used to generate the correlation coefficients shown in Figure 7.1 and Figure 7.2. Correlations with only seven data points may lack statistical power or give rise to spurious findings. The correlation coefficients must therefore be interpreted with caution. Despite this, where correlations were significant at $p<.05$, there was clear correspondence between that social norm and strength of policies and prevalence rates (Figure 7.1 and Figure 7.2).

7.3.1. Conclusion

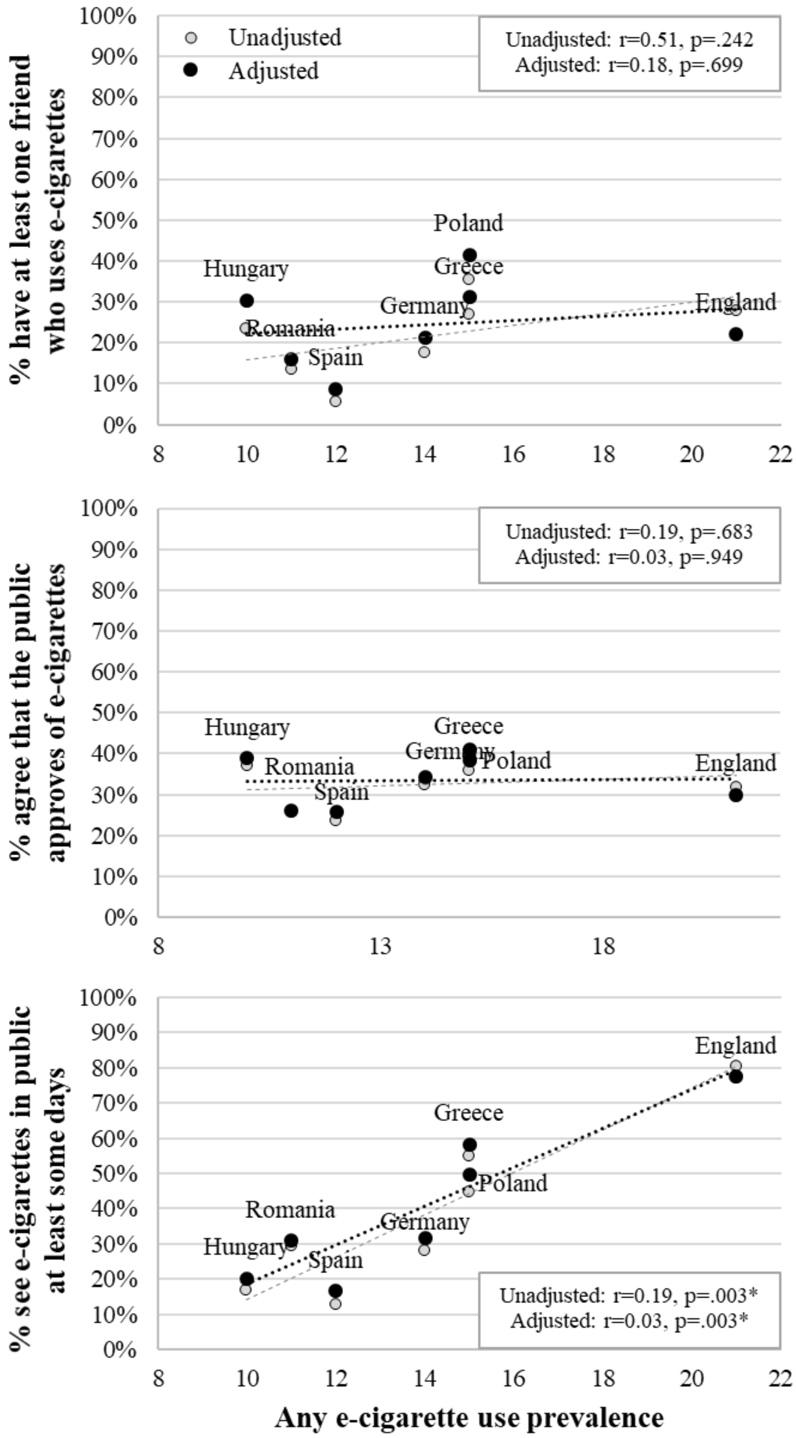
My findings from this Chapter (Chapter 7) suggest that smoking and vaping norms among adult smokers in Europe do not always correspond with policies and prevalence rates, contrary to theorised [4]. The descriptive norms of friend smoking and seeing vaping in public were generally more common among adult smokers from countries with greater smoking prevalence rates and vaping prevalence rates, respectively [4]. Friend smoking was also generally more common among adult smokers from countries with weaker tobacco control policies [4]. Except England, smokers' injunctive norms towards smoking and vaping generally did not correspond with smoking and vaping prevalence rates, respectively. My findings suggest that smokers' descriptive, but not injunctive, norms may be related to policies and prevalence rates.

Figure 7.1. Correlations between unadjusted and adjusted estimates of each smoking social norm among adult smokers across seven European countries and smoking prevalence (left panels) and Tobacco Control Scale scores (right panels)



The unadjusted estimates are the same as those presented in Table 2 in the publication in this Chapter (Section 7.2) [4]. The adjusted estimates were generated from the logistic regression models described in the publication above [4] using Stata's margins command [259]. These estimates adjusted for age, age, sex, income, education, smoking status, current e-cigarette use, and heaviness of smoking index. Estimates used multiply imputed datasets with survey weights and strata. r=Pearson's correlation coefficient. *=p<.05.

Figure 7.2. Correlations between unadjusted and adjusted estimates of each vaping social norm among adult smokers across seven European countries and vaping prevalence



The unadjusted estimates are the same as those presented in Table 2 in the publication in this Chapter (Section 7.2) [4]. The adjusted estimates were generated from the logistic regression models described in the publication above [4] using Stata's margins command [259]. These estimates adjusted for age, age, sex, income, education, smoking status, current e-cigarette use, and heaviness of smoking index. Estimates used multiply imputed datasets with survey weights and strata. r=Pearson's correlation coefficient. *=p<.05.

7.4. Impact and dissemination

My publication above was part of the EUREST-PLUS project and was published as part of a EUREST-PLUS supplement in the journal Tobacco Induced Diseases [229]. EUREST-PLUS is a Horizon 2020 Project led by researchers throughout Europe and wider, which aims to monitor and evaluate the EU TPD [59, 230]. My publication therefore forms part of a larger body of evidence evaluating the impact of tobacco and nicotine product regulations across the EU.

As of 24th September 2019, my publication had been cited twice. I presented this work as a poster at The Society for Research on Nicotine and Tobacco (SRNT) 2019 Annual Meeting in San Francisco, US, and also this same poster at the Institute of Psychiatry, Psychology, and Neuroscience Student Showcase in London, England (poster available online at [14]).

CHAPTER 8

Trends in Smoking Norms Over Time Among Daily Smokers Across UK, Canada, US, Australia

8.1. Preface

The implementation of comprehensive tobacco control policies alongside decreasing smoking prevalence have led to the assumption that smoking has become denormalised over time. However, prior to my PhD there had been no formal assessment of this. Further, my findings exploring differences in smoking and vaping norms across countries among youth (in Chapter 6 [3]) and adult smokers in Europe (in Chapter 7 [4]) suggested possibly more complex associations between norms, policies, and prevalence rates.

In this Chapter I extended my findings from Chapter 6 [3] and Chapter 7 [4] to assess (i) trends in smoking norms and opinions between 2002 and 2015 and (ii) differences in smoking norms and opinions across countries among adult daily smokers in the UK, Canada, the US, and Australia.

These objectives relate to *Aim 6* of my thesis: To assess, among adult smokers (and youth), whether smoking norms correspond with tobacco control policies and smoking prevalence rates.

I addressed these objectives, and hence thesis aims, in my fifth peer-reviewed publication, which is presented in Section 8.2 below [5]:

East, K., Hitchman, S. C., McNeill, A., Ferguson, S., Yong, H. H., Cummings, M. K., Fong, G. T., & Borland, R. (in press, available online). Trends in social norms towards smoking between 2002 and 2015 among daily smokers: Findings from the International Tobacco Control Four Country Survey (ITC 4C). Nicotine and Tobacco Research. doi: 10.1093/ntr/ntz179.

I have provided this publication as the authors' accepted manuscript because it was in press at the time of my thesis submission [5]. I have included a discussion contextualising the findings into this thesis below the publication, in Section 8.3. I have also included a summary of the impact and dissemination of this work, in Section 8.4.

The supplementary materials referred to in my publication [5] are available in Appendix I of this thesis.

8.1.1. Declaration of roles

This publication [5] was developed in collaboration with Dr Sara C Hitchman and Professor Ann McNeill (King's College London), Dr Stuart G Ferguson (The University of Tasmania), Dr Hua-Hie Yong and Professor Ron Borland (Cancer Council Victoria), Professor K Michael Cummings (The Medical University of South Carolina) and Geoffrey T Fong (The University of Waterloo). KMC and GTF were the Principal Investigators of the International Tobacco Control Policy Evaluation (ITC) Project Four Country Survey and designed the survey together with Co-Investigators RB and AM. The survey and measures were developed in collaboration with the ITC Project Research Team and survey firms (see [234-236] for full details). The ITC Project Research Team and survey firms were responsible for sample recruitment and maintenance. SCH and HY also provided input on the survey design and measures. I led the write-up of this publication [5], formulated the research questions, and analysed the data, with input from SCH, AM, SGF, HY, and RB. All co-authors reviewed and provided input on drafts of the publication [5]. I undertook this work during my research visit to The

University of Tasmania (with SGF) and Cancer Council Victoria (with HY and RB) and completed the write-up at King's College London (with SCH and AM).

8.1.2. Selection of social norms measures

In this publication [5] I used data from the 2002-2015 ITC Project Four Country Survey, which was developed prior to starting my PhD. I selected three measures of smoking norms and one measure of opinion of smoking* for use in this publication: friend smoking, perceiving that people important to you believe you should not smoke, perceived societal disapproval of smoking, and negative opinion of smoking* (see Table 3.1). I selected these measures because they were the only measures of social norms that were consistently measured both across countries and over time. Opinion of smoking was selected to complement the social norms measures and because it was consistently measured both across countries and over time.

8.2. Accepted manuscript

Trends in social norms towards smoking between 2002 and 2015 among daily smokers: Findings from the International Tobacco Control Four Country Survey (ITC 4C)

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Keywords: Longitudinal research, population studies, public health, sociology, survey research, tobacco control

ABSTRACT

Objective: To assess trends in daily smokers' social norms and opinions of smoking between 2002 and 2015 in Canada, US, UK and Australia.

Method: Data were from Waves-1 (2002) to -9 (2013-2015) of the longitudinal International Tobacco Control Four Country Survey (Canada, US, UK, Australia), involving 23,831 adult daily smokers. Generalised estimating equation logistic regression models, adjusted for demographics and survey design effects, assessed associations of Wave and country with outcomes: (i) over half of five closest friends smoke, (ii) agreeing that people important to you believe you should not smoke, (iii) agreeing that society disapproves of smoking, and (iv) negative opinion of smoking.

Results: Between 2002 and 2015, adjusting for covariates, (i) over half of five closest friends smoke did not change (56% vs. 55%; Adjusted Odds Ratio [AOR]=0.95[95% Confidence Interval=0.85-1.07]), (ii) agreeing that people important to you believe you should not smoke generally decreased (89% vs. 82%; AOR=0.54[0.46-0.64]) despite an increase around 2006-2007, (iii) agreeing that society disapproves of smoking increased between 2002 and 2006-2007 (83% vs. 87%; AOR=1.38[1.24-1.54]) then decreased until 2013-2015 (78%; AOR=0.74[0.63-0.88]), and (iv) negative opinion of smoking decreased between 2002 and 2010-2011 (54% vs. 49%; AOR=0.83[0.75-0.91]) despite an increase around 2005-2006 and at the final Wave (2013-2015). Except friend smoking, Canada had the greatest, and UK the lowest, anti-smoking social norms and opinions.

Conclusions: Except friend smoking and opinion of smoking, daily smokers' social norms became less anti-smoking between 2002 and 2015 despite increases around 2006-2007. Several potential explanations are discussed yet remain undetermined.

IMPLICATIONS

Increasingly comprehensive tobacco control policies alongside decreasing smoking prevalence in Canada, the US, the UK, and Australia have led to the assumption that smoking has become increasingly denormalised in these countries. Absent from the literature is any formal assessment of social norms towards smoking over time. Contrary to our hypotheses, this study found that the injunctive social norms of daily smokers became less anti-smoking between 2002 and 2015, despite increases around 2006-2007. There was no change over time in the proportion of daily smokers who report that over half of their five closest friends smoke.

INTRODUCTION

Social norms have an important impact on human behaviour,[1-4] and can be categorised into two distinct domains. Descriptive norms refer to a person's perceptions of how others behave (e.g. how common smoking is), while injunctive norms refer to a person's perceptions of how others think people ought to behave (e.g. approval of smoking).[2-4] By extension, denormalisation is the process of changing a person's perceptions about a behaviour from more common and/or approved to less common and/or approved; renormalisation is the reverse.

Social norms towards tobacco smoking can be important sources of influence for smoking intentions, uptake, and cessation.[5-9] Several tobacco control efforts focus on the denormalisation of smoking and, in conceptual models, normalisation beliefs are often placed on the causal pathway between tobacco control policies and behavioural outcomes.[10,11] Many efforts have been found to reduce smoking prevalence and promote cessation,[12-15] and smoking prevalence has decreased alongside increasingly comprehensive tobacco control policies.[16] Smoking is thus theorized to have become increasingly denormalised in many Western countries. Indeed, a recent study among British youth found that both prevalence of smoking and prevalence of perceiving that smoking is OK have decreased between 1998 and 2015.[17] However, there is no research of which we are aware assessing both descriptive and injunctive norms towards smoking over time.

This paper uses data from the four countries of the International Tobacco Control 4 Country Survey (ITC 4C), Canada, the US, the UK and Australia, collected between 2002 and 2015, to assess trends in social norms over time. This century there have been increasingly comprehensive tobacco control policies in Canada, the US, the UK, and Australia (Figure 1). While there are similarities between these countries, there are important differences, with the US generally lagging in the implementation of several tobacco control initiatives, including updated health warnings, retail cigarette marketing restrictions, and nationwide smoke-free policy (Figure 1). Since 2002, the UK has had the highest, and Australia the lowest, prevalence of tobacco smoking,[18] and in all four countries prevalence has decreased.[18] Kasza et al.[19] assessed reasons smokers think about quitting between 2002 and 2015 in these four countries, and found an upward trend in societal disapproval of smoking as a reported reason for quitting in the US, a downward trend in Canada, and non-linear trends in UK and Australia, suggesting possible differential trends between countries.

This study uses daily smokers from the longitudinal ITC 4C (Canada, US, UK, Australia) to assess trends between 2002 and 2015 in: one descriptive norm (i) reporting that over half of your five closest friends smoke; two injunctive norms, agreeing that (ii) people important to you believe you should not smoke, and (iii) society disapproves of smoking; and (iv) respondents' overall opinion of smoking. Given increased smoking restrictions and decreased prevalence, we hypothesized that all four measures would indicate denormalisation of smoking over time, although the Kasza et al.[19] study suggests possibly more complex relationships. Between-country differences are also explored.

METHODS

Pre-registration

The analysis plan was pre-registered on the Open Science Framework.[20]

Sample

This study used data from Waves-1 (2002) to -9 (2013-2015) of the longitudinal ITC 4C Survey in Canada, the US, the UK, and Australia. Details about the sampling and design are described elsewhere.[21-23] Briefly, nationally representative samples of ~2000 current smokers (≥100 cigarettes in lifetime and ≥1 cigarette in the past 30 days) age 18+ were recruited from each country. All respondents were re-contacted annually, and new smokers were recruited to offset attrition. Waves-1-6 used Computer Assisted Telephone Interviewing (CATI). Waves-7-9 used CATI and internet surveys. Wave-to-Wave recruitment response rates (for newly recruited respondents) ranged from 13% (UK, Wave-5) to 50% (Canada, Wave-3); Wave-to-Wave follow-up rates (for recontacted respondents), ranged from 66% (UK, Wave-5) to 91% (Australia, Wave-3).[21,22] Prior analyses have found good correspondence between the demographic profiles of ITC Four

Country Survey respondents and national benchmark surveys.[21-23] This study included only daily smokers at each Wave (23,831 respondents, 57,086 observations). Respondents who quit and relapsed to daily smoking were added back into the sample when they relapsed.

Measures

Outcome variables

(i) Over half of five closest friends smoke: "Of the five closest friends or acquaintances that you spend time with on a regular basis, how many of them are smokers? 0-5". For analyses, responses were dichotomised as under half (0-2) vs. over half (3-5), similar to previous ITC studies.[24] Responses were dichotomised because the assumptions of (1) normality of residuals and homoscedasticity for linear regression, and (2) proportional odds for ordinal logistic regression were violated.[20]

(ii) People important to you believe you should not smoke: "People who are important to you believe that you should not smoke. Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree". For analyses, responses were dichotomised as agree (Strongly Agree, Agree) vs. not agree (Neither Agree nor Disagree, Disagree, Strongly Disagree).

(iii) Society disapproves of smoking: "Society disapproves of smoking. Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree". For analyses, responses were dichotomised as agree (Strongly Agree, Agree) vs. not agree (Neither Agree nor Disagree, Disagree, Strongly Disagree).

(iv) Opinion of smoking: "What is your overall opinion of smoking? Is it...? Very Positive, Positive, Neither Positive nor Negative, Negative, Very Negative". For analyses, responses were dichotomised as negative (Negative, Very Negative) vs. not negative (Very Positive, Positive, Neither Positive nor Negative). Coding deviated from the pre-registration[20] because 11.2% of respondents answered "Very positive" or "Positive", therefore negative opinion was modelled as the majority response.

Predictor variables

Survey Wave: 1 (collected in 2002), 2 (2003), 3 (2004), 4 (2005-2006), 5 (2006-2007), 6 (2007-2008), 7 (2008-2009), 8 (2010-2011), and 9 (2013-2015) (Figure 1).

Country: Canada, US, UK, Australia.

Covariates

Covariates measured at baseline: age (18-24, 25-39, 40-54, 55+), gender (male, female), ethnicity (majority, minority).

Covariates measured at each Wave: Annual household income (low, moderate, high, no answer), education (low, moderate, high, no answer), Heaviness of Smoking Index (HSI)[25] (0-6, 6=greater dependence), survey mode (telephone, internet), time-in-sample (1-9 Waves; number of Waves respondent was involved in), and time-between-Waves (0-3.5 years; time since respondent last completed a survey). Time-in-sample was included to control for potential participation effects;[23,26] time-between-Waves was included because the time between survey Waves differed by country towards the end of the study and we wanted to control for these differences. The questionnaires[27] and details on coding of income, education, and ethnicity[19,20] are available elsewhere.

Analyses

Four logistic regression models were estimated using Generalised Estimating Equations (GEE) to assess associations between each outcome (i)-(iv) and country and Wave, adjusting for covariates. Average probabilities of each social norm (i)-(iv) were predicted from these models using Stata's margins command and plotted; this differed from the pre-registration because the results were influenced by time-in-sample.[20] GEE account for correlations in the longitudinal data. Correlations between observations from the same individuals were modelled specifying an unstructured within-person correlation matrix.

First, Wave was first treated as categorical to aid interpretation of non-linear trends. Second, Wave was treated as continuous and linear, quadratic, and cubic trends were assessed for (i)-(iv) using hierarchical logistic regression (Model 1(linear): Wave+country+covariates; Model 2(quadratic): $Wave^2$+Wave+country+covariates; Model 3(cubic): $Wave^3$+$Wave^2$+Wave+country+covariates); the highest-order significant ($p<.05$) model was reported for each of (i)-(iv). Third, Wave (categorical) by country interactions were assessed for (i)-(iv); where interactions were observed ($p<.05$), average predicted probabilities were plotted using Stata's margins command and compared pairwise using 99% confidence intervals due to multiple comparisons. Linear, quadratic, and cubic trends, and interactions, deviated from the pre-registration following observation of linear and non-linear trends.[20]

Country was treated as a time-invariant, and Wave as a time-variant, predictor. Age, gender, and ethnicity were treated as time-invariant covariates. Income, education, HSI, survey mode, time-in-sample and time-between-Waves were treated as time-variant covariates. Only the results for Wave and country are reported below.

Analyses were run using Stata v15.[28] All data were weighted. Weights were calculated using estimated population values from national benchmark surveys incorporating gender, age, and region.[21-23]

Missing data

For outcomes (i)-(iv), all "Not applicable", "Refused", and "Don't know" responses were coded as missing and multiple imputation (MI) was used for these values: friend smoking (n=2,057, 3.54%, observations imputed), people important to you believe you should not smoke (n=1,626, 2.79%), society disapproves of smoking (n=1,822, 3.13%), opinion of smoking (n=2,113, 3.63%). MI was also used for missing data on income (n=1,153, 1.98%) and HSI (n=1,994, 3.43%), which deviated from the pre-registration due to unanticipated missing data on these two covariates.[20] There were no missing data on any other variables. Data were not Missing-Completely-At-Random, because Wave, age, gender, ethnicity, education, mode, time-in-sample, and time-between-Waves were associated with missingness ($p<.05$). Data were therefore assumed to be Missing-At-Random.

Missing values were imputed using chained equations. One model was used specifying imputation via multinomial logistic regression for all social norms measures, income, and HSI, with country, age, gender, ethnicity, education, survey mode, time-in-sample, time-between-Waves, Wave (categorical, linear, quadratic, cubic), and Wave (linear, quadratic, cubic) by country interactions as predictors. Survey weights were included. Twenty imputed datasets were created because <30% of data were missing.[29] MI results in valid statistical inferences that reflect uncertainty due to missing values while enabling sample size to be maximised.[30]

Sensitivity analyses

The following sensitivity analyses were conducted to identify potential problems with estimation: (1) prevalence estimates and logistic regression GEE with MI vs. complete case analyses, (2) logistic regression GEE specifying an unstructured vs. exchangeable correlation matrix, (3) prevalence estimates for the re-contacted vs. newly recruited samples (additional to pre-registration[20]). The interpretation of the results remained unchanged during all sensitivity analyses.

RESULTS

Sample characteristics

Of the 23,831 respondents, 5,545 were from Canada, 7,832 from US, 5,421 from UK, and 5,033 from Australia. The modal demographic categories were 25-54-years, male, majority ethnicity, and moderate household income and education (Table 1). Most were recruited in Wave-1 and took part in only one survey Wave (Table 1). Supplementary Table 1 has further details on the sample characteristics at each Wave.

Over half of five closest friends smoke

Trend

At Wave-1 (2002), 55.6% (adjusted for covariates) reported that over half of their five closest friends smoke and this showed little change over time (Figure 2i;

Table 2i). There was also little evidence of any linear, quadratic, or cubic trends (Table 2i).

There was a declining trend in unadjusted prevalence at each Wave (Supplementary Table 2) but this was found to be an artefact of time-in-sample: in unadjusted GEE logistic regression, the odds of having over half of friends smoke decreased between Wave-2 (2003) and Wave-9 (2013-2015) (all OR<1.00, p<.05; data not shown), yet when time-in-sample was added this association was attenuated (all p>.05; data not shown). As time-in-sample increased the odds of having over half of friends smoke decreased (Supplementary Table 3).

We also explored whether reporting "at least one of five closest friends smoke" (0 vs. 1-5) changed over time, for comparison (additional to the pre-registration).[20] Except a slight increase from 87.6% (adjusted for covariates) at Wave-1 (2002) to 89.0% at Wave-5 (2006-2007; AOR=1.15[1.03-1.29], p=.014), there was little change over time in reporting that at least one of five closest friends smoke (all p>.05; data not shown).

Between-country differences

Respondents from US had greater odds of having over half of their five closest friends smoke compared with Canada and Australia (Table 2i).

Wave-by-country interactions

There was a Wave-by-country interaction (F(24,1200000)=1.73, p=.015), such that there was no change over time in Canada, US or Australia, but in UK, compared with Wave-2 (2003), friend smoking was lower at Wave-4 (2005-2006) and Wave-9 (2013-2015) (Supplementary Figure 1, left panels).

People important to you believe you should not smoke

Trend

At Wave-1 (2002), 89.0% (adjusted for covariates) agreed that people important to you believe you should not smoke (Figure 2ii). This decreased to 85.3% at Wave-2 (2003), increased gradually to 88.2% at Wave-5 (2006-2007) and subsequently decreased again to 81.6% at Wave-9 (2013-2015) (Figure 2ii; Table 2ii). Trends analyses indicated a cubic trend (Table 2ii; with $p \leq .001$ for all AORs for the linear, quadratic, and cubic Wave terms) reflecting the decrease, increase, and decrease again in agreement that people important to you believe you should not smoke. These results were similar to the unadjusted prevalence at each Wave (Supplementary Table 2).

Between-country differences

Respondents from Canada had greater odds of agreeing that people important to you believe you should not smoke compared with UK and Australia, and those from Australia and US had greater odds of agreeing that people important to you believe you should not smoke compared with UK (Table 2ii).

Wave-by-country interactions

There was little evidence of a Wave-by-country interaction ($F(24,3200000)=1.41$, $p=.086$), suggesting the association between Wave and agreeing that people important to you believe you should not smoke did not differ by country.

Society disapproves of smoking

Trend

At Wave-1 (2002), 82.9% (adjusted for covariates) agreed that society disapproves of smoking (Figure 2iii). This increased to 86.9% at Wave-5 (2006-2007), then decreased to 78.3% until Wave-9 (2013-2015) (Figure 2iii; Table 2iii). Trends analyses indicated a quadratic trend (Table 2iii; with $p<.001$ for both AORs for the linear and quadratic Wave terms), reflecting the increase and subsequent decrease in agreement that society disapproves of smoking. These results were similar to the unadjusted prevalence at each Wave (Supplementary Table 2).

Between-country differences

Respondents from Canada had greater odds of agreeing that society disapproves of smoking compared with US, UK, and Australia, and those from Australia had greater odds than UK (Table 2iii).

Wave-by-country interactions

There was a Wave-by-country interaction ($F(24,1500000)=1.77$, $p=.011$), such that in US, UK, and Australia agreeing that society disapproves of smoking increased between Wave-1 (2002) and Wave-5 (2006-2007) then decreased between Wave-5 (2006-2007) and Wave-9 (2013-2015), whereas in Canada there was no change between Wave-1 (2002) and Wave-6 (2007-2008) yet a decrease between Wave-6 (2007-2008) and Wave-9 (2013-2015) (Supplementary Figure 1, centre panels).

Negative opinion of smoking

Trend

At Wave-1 (2002), 53.8% (adjusted for covariates) had a negative opinion of smoking (Figure 2iv). This decreased to 50.2% at Wave-2 (2003), increased gradually to 53.1% at Wave-4 (2005-2006), decreased gradually again to 49.1% at Wave-8 (2010-2011) and sharply increased again to 54.8% at Wave-9 (2013-2015) (Figure 2iv; Table 2iv). Trends analyses indicated a quadratic trend (Table 2iv; with $p \leq .001$ for both AORs for the linear and quadratic Wave terms), reflecting the overall linear downwards trend with a slight increase between Waves-2-4 and some recovery of negative opinion at the final Wave. Except Wave-9, these results were similar to the unadjusted prevalence at each Wave (Supplementary Table 2).

Between-country differences

Respondents from Canada had greater odds of having a negative opinion of smoking compared with US, UK, and Australia (Table 2iv). Those from Australia had greater odds of having a negative opinion of smoking compared with US and UK (Table 2iv).

Wave-by-country interactions

There was a Wave-by-country interaction (F(24,828753.4)=1.77, p=.011), such that in Canada negative opinion of smoking decreased between Wave-1 (2002) and Wave-8 (2010-2011), yet increased between Wave-8 (2010-2011) and Wave-9 (2013-2015), while in UK negative opinion increased between Wave-2 (2003) and Wave-4 (2005-2006) then remained unchanged (Supplementary Figure 1, right panels). There was no change over time in US or Australia (Supplementary Figure 1, right panels).

DISCUSSION

We hypothesised that all four measures used in this study would indicate denormalisation of smoking between 2002 and 2015. Contrary to our hypotheses: the descriptive norm (i) reporting that over half of five closest friends smoke did not change after adjusting for covariates; the two injunctive norms, agreeing that (ii) people important to you believe you should not smoke, and (iii) society disapproves of smoking, generally decreased between 2002 and 2013-2015 despite increases around 2006-2007; (iv) negative opinion of smoking generally decreased between 2002 and 2010-2011 despite an increase around 2005-2006 and some recovery at the final Wave (2013-2015). Trends were similar across the four countries, and Canada had the greatest, and UK the lowest, anti-smoking injunctive norms and opinions.

This study finds that there has been a shift towards less anti-smoking injunctive norms among daily smokers, beginning around 2006/2007. These results complement a previous study using the same ITC 4C dataset,[19] which assessed societal disapproval of smoking as a reported reason for quitting and failed to find any clear increases from 2002-2015, except in the US. There are several speculated reasons for these trends, discussed below.

The first explanation for the shift towards less anti-smoking injunctive norms among daily smokers from around 2006/2007 is smoke-free legislation. By 2006/2007, smoke-free policies were fully implemented in the UK and Australia, in seven of ten Canadian provinces, and in thousands of local communities and seven states covering most of the US population (Figure 1). Because rules limiting smoking in public had become commonplace and accepted by smokers and non-smokers, and because reduced opportunities to smoke might have led smokers to reduce their cigarette consumption,[26] smokers may perceive less disapproval from those around them. However, this proposition would be difficult to assess.

Second, the introduction of social media platforms, such as Twitter, Facebook, and YouTube, around 2005/2006 may have contributed towards less anti-smoking injunctive norms and changing opinions. Pro-smoking online content is widely available,[31] and previous research has indicated associations with social norms and attitudes towards smoking.[32] Moreover, the internet might give rise to extremist bloggers or a more widespread distrust in the government and public health experts, which could be linked to normalisation beliefs. Therefore, social media may challenge anti-smoking norms and/or perpetuate existing pro-smoking norms; this may have magnified over time with increasingly widespread and sophisticated platforms.

There are also some explanations for the general downwards trends in injunctive norms and negative opinion of smoking that are unlikely, but some may think plausible. There are debated concerns that the introduction of electronic cigarettes (e-cigarettes) in the mid-2000s, and the increase in their marketing and use, could “renormalise” smoking.[33-36] However, e-cigarettes only became popular since around 2010,[37] yet the shift in norms and opinions was seen from 2006/2007. Policies such as mass media campaigns, sponsorship and advertising bans, and taxation (Figure 1) also constitute unlikely explanations, since it is difficult to see any clear pattern corresponding with the trends observed. Perhaps a more plausible explanation is that lower smoking prevalence and numerous tobacco control policies may have led to a presumption that smoking is no longer a public health priority, given obesity, dementia, opioids, and other competing health concerns. However, these explanations cannot account for the increases around 2006/2007, or the trend in opinion of smoking.

Finally, it is possible that smoking is no longer seen as a societal problem due to increasing disparities in smoking prevalence between advantaged and disadvantaged groups in the four countries. Daily smokers are more likely to be of lower socio-economic status,[38-40] older,[40] and have weaker anti-smoking norms.[5] Therefore, the individuals in this study may represent a group who are increasingly marginalised, being aware of the dangers of smoking but lacking the resources to quit. Such individuals may hold more entrenched or polarised social norms and opinions, or adopt a siege mentality, which may be increasingly pronounced with decreasing smoking prevalence and wide-scale adoption of tobacco control policies. Tobacco has also become less affordable over time, particularly among those of lower socioeconomic status,[41] leading to further disparities and perhaps further resentment particularly among disadvantaged groups. However, as above, these explanations cannot account for the increases around 2006/2007, unless any marginalisation effects were amplified by smoke-free policy, and although our sample did become older over time they also became better educated and less heavy smokers (Supplementary Table 1), counter to the idea of increased marginalisation.

The implications of changing social norms and opinions of daily smokers are unclear. Descriptive and injunctive norms have been associated with smoking behaviours and intentions.[5-9,42] However, adult smoking prevalence has decreased from 2002-2015 alongside increasingly comprehensive policies in all four ITC 4C countries.[18] This may question whether smoking denormalisation is a valid approach to tobacco control, or at least that smoker's social norms may be less related to smoking policies and prevalence rates than theorized;[10,11,43] this reflects findings for injunctive norms from a recent ITC study in Europe.[24] Despite this, Kasza et al.[19] found that reporting societal disapproval as a reason to quit smoking increased the odds of making a quit attempt. It is therefore possible that the observed trends could pre-empt an attenuation of declines in smoking. In the literature, concerns about smoking "renormalisation" focus on e-cigarettes promoting youth smoking uptake;[36,44,45] it is important to not generalise such arguments to the changing social norms of daily adult smokers seen in this study, especially given evidence that e-cigarettes can help some smokers quit.[46] Moreover, a recent study among British youth found that prevalence of perceiving smoking as OK decreased from 1998-2015,[17] contrary to our findings; trends in norms and opinions may thus differ across different groups. Ongoing longitudinal surveys, such as the ITC Surveys and US Population Assessment of

Tobacco and Health Surveys, are critical to continue monitoring norms and extend our findings among smokers, non-smokers, and those who quit smoking.

Consistent with previous studies,[5] overall, smokers in Canada had the greatest, and the UK the lowest, anti-smoking injunctive norms and negative opinion of smoking. These differences could be explained by a longer history of anti-smoking policies in Canada compared with the UK.[5] Both trends and country differences in having over half of five closest friends who smoke showed little obvious relation to smoking policies (Figure 1) or prevalence rates.[18] This is in contrast to a recent cross-sectional ITC study among smokers, which did find that friend smoking was higher in European countries with greater smoking prevalence.[24] While there are some differences between the four ITC 4C countries, their policies are all anti-smoking to a large degree (Figure 1). There may be greater contrast in levels of social norms and trends over time in low- and middle-income countries at earlier stages of the tobacco epidemic.

It is important to consider this study's limitations. First, the sample involved adult daily smokers who, as stated above, represent a unique group. The results therefore cannot be generalized to the social norms or opinions of non-daily smokers, quitters, never-smokers, or youth; replication is required using surveys of the general population in each country. Second, although the adjusted odds of having over half of five closest friends smoke did not change over time, odds of having *at least one* slightly increased at 2006-2007. Average number of smoking friends may have shown further changes but could not be assessed due to violation of linear and ordinal logistic regression assumptions. Third, there is some lack of clarity as to what these social norms measures mean. For example, following the implementation of smoke-free policies, daily smokers might perceive less societal disapproval because they experience fewer negative reactions, rather than due to any true change in societal disapproval. More nuanced measures of social norms, assessed among both smokers and non-smokers, may aid interpretation of findings. Fourth, most participants only took part in one survey Wave which may have impacted the findings, particularly because time-in-sample had an effect on friend smoking and perceived societal disapproval of smoking; however, we adjusted for time-in-sample and sensitivity analyses indicated similar results for the re-contacted and newly recruited samples.

Strengths include large sample size, weighted and nationally representative data, adjustment for demographics associated with social norms,[5] and adjustment for survey characteristics which may influence responses. Further, this study was the first to our knowledge to longitudinally and consistently assess social norms and opinions of smoking over time and across countries and has raised important issues regarding how they might be changing.

To conclude, injunctive social norms of daily smokers have generally become less anti-smoking between 2002 and 2015, despite increases around 2006/2007. There was no change in reporting that over half of five closest friends smoke. Trends were similar across the four countries, although there were overall differences with Canada generally having the greatest, and UK the lowest, anti-smoking injunctive norms and opinions. While country differences might be explained to an extent by different tobacco control policies, common trends were contrary to our hypotheses and so the proposed explanations should be considered tentative until further research identifies which, if any, may be implicated.

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Table 1. Sample characteristics at Wave of recruitment for each respondent. Data are weighted.

%	Canada n=5,545	US n=7,832	UK n=5,421	Australia n=5,033	Overall n=23,831
Age (years)					
18-24	12.46	13.52	13.14	14.23	13.34
25-39	32.04	29.97	32.70	35.52	32.23
40-54	35.37	34.98	29.93	32.84	33.47
55+	20.14	21.53	24.24	17.41	20.96
Gender: female	46.21	46.33	49.10	45.43	46.75
Ethnicity: majority	88.84	78.84	94.17	87.51	86.47
Annual household income					
Low	25.80	37.63	28.76	25.51	30.33
Moderate	32.95	32.31	32.16	32.95	32.98
High	30.83	24.50	29.62	34.74	29.28
No answer	8.58	5.57	9.46	6.79	7.41
Education					
Low	49.39	47.66	58.73	64.46	54.08
Moderate	35.81	38.07	26.95	22.23	31.71
High	14.37	14.17	13.55	12.97	13.83
No answer	0.43	0.10	0.76	0.34	0.38
HSI[1] (mean (SE[2]))	2.89 (0.02)	2.84 (0.02)	2.66 (0.02)	2.95 (0.03)	2.83 (0.01)
Wave of recruitment					
Wave-1	37.07	25.09	41.67	42.57	35.30
Wave-2	8.59	8.10	4.11	4.63	6.58
Wave-3	9.16	10.65	10.38	9.78	10.06
Wave-4	8.77	8.81	8.95	6.77	8.41
Wave-5	10.13	9.04	10.42	12.80	10.39
Wave-6	9.26	8.53	9.11	9.98	9.13
Wave-7	5.61	4.46	6.25	2.24	4.67
Wave-8[3]	3.45	4.32	0.00	3.84	3.03
Wave-9	7.98	21.00	9.12	7.40	12.42
Time-in-sample					
1 Wave	39.06	52.40	39.34	35.97	41.90
2 Waves	22.10	20.61	22.83	22.61	22.01
3 Waves	14.05	11.10	14.55	14.60	13.52
4 Waves	9.45	6.89	9.53	10.51	9.05
5 Waves	5.95	4.03	5.95	6.48	5.57
6 Waves	4.08	2.38	3.57	4.20	3.54
7 Waves	2.71	1.39	2.29	2.91	2.31
8 Waves	1.71	0.82	1.25	1.73	1.37
9 Waves	0.89	0.38	0.68	1.00	0.73

[1] HSI=Heaviness of Smoking Index. [2] SE=standard error. [3] There was no replenishment at Wave-8 in UK due to resource constraints.

Table 2. Adjusted associations between Wave and country and (i) having over half of five closest friends smoke, (ii) agreeing that people important to you believe you should not smoke, (iii) agreeing that society disapproves of smoking, and (iv) having a negative opinion of smoking, among daily smokers (N=57,086 observations from 23,831 respondents)

	(i) Over half of five closest friends smoke		(ii) Agree that people important to you believe you should not smoke		(iii) Agree that society disapproves of smoking		(iv) Negative opinion of smoking	
	AOR (95% CI)	p	AOR (95% CI)	p	AOR (95% CI)	p	AOR (95% CI)	p
Wave								
Categorical								
1 - 2002 (ref)	1.00		1.00		1.00		1.00	
2 - 2003	1.04 (0.98-1.10)	.250	**0.71 (0.65-0.78)**	**<.001**	1.03 (0.94-1.12)	.557	**0.86 (0.81-0.91)**	**<.001**
3 - 2004	1.03 (0.96-1.10)	.477	**0.77 (0.69-0.86)**	**<.001**	**1.22 (1.11-1.35)**	**<.001**	**0.88 (0.82-0.94)**	**<.001**
4 - 2005-2006	0.98 (0.92-1.06)	.673	0.90 (0.81-1.01)	.072	**1.31 (1.18-1.47)**	**<.001**	0.97 (0.91-1.04)	.423
5 - 2006-2007	1.00 (0.93-1.08)	.998	0.92 (0.82-1.04)	.178	**1.38 (1.24-1.55)**	**<.001**	**0.93 (0.86-1.00)**	**.045**
6 - 2007-2008	1.06 (0.98-1.15)	.137	**0.73 (0.65-0.83)**	**<.001**	**1.32 (1.17-1.48)**	**<.001**	**0.89 (0.82-0.96)**	**.002**
7 - 2008-2009	1.04 (0.95-1.13)	.433	**0.62 (0.55-0.71)**	**<.001**	1.06 (0.94-1.20)	.314	**0.86 (0.79-0.94)**	**.001**
8 - 2010-2011	1.02 (0.92-1.13)	.747	**0.67 (0.57-0.78)**	**<.001**	0.89 (0.77-1.03)	.130	**0.83 (0.75-0.91)**	**<.001**
9 - 2013-2015	0.95 (0.85-1.07)	.436	**0.54 (0.46-0.64)**	**<.001**	**0.74 (0.63-0.87)**	**<.001**	1.04 (0.93-1.17)	.503
Linear (Wave)	1.00 (0.99-1.01)	.971	**0.77 (0.67-0.89)**	**<.001**	**1.28 (1.22-1.34)**	**<.001**	**0.95 (0.92-0.99)**	**.005**
Quadratic ($Wave^2$)	1.00 (0.995-1.01)	.395	**1.06 (1.03-1.10)**	**.001**	**0.97 (0.97-0.98)**	**<.001**	**1.00 (1.001-1.01)**	**.008**
Cubic ($Wave^3$)	1.00 (0.998-1.01)	.425	**0.995 (0.99-0.998)**	**<.001**	1.00 (0.996-1.000)	.115	1.00 (0.999-1.002)	.603
Country								
Canada (ref)	1.00		1.00		1.00		1.00	
US	**1.10 (1.03-1.19)**	**.007**	0.99 (0.89-1.10)	.822	**0.63 (0.57-0.69)**	**<.001**	**0.71 (0.66-0.77)**	**<.001**
UK	1.03 (0.96-1.11)	.453	**0.58 (0.52-0.64)**	**<.001**	**0.59 (0.54-0.65)**	**<.001**	**0.66 (0.62-0.71)**	**<.001**
Australia	0.94 (0.87-1.02)	.131	**0.84 (0.75-0.94)**	**.003**	**0.74 (0.67-0.82)**	**<.001**	**0.88 (0.81-0.95)**	**.001**

AOR=Adjusted Odds Ratio, adjusted for age, gender, ethnicity, income, education, HSI, survey mode, time-in-sample, time-between-Waves. 95% CI=95% confidence interval. 95% CIs are reported to 3 decimal places where they are close to 1.00 (±0.005). For linear, quadratic, and cubic Wave terms, the results are reported from the highest-order significant (p<.05) model (cubic for outcome (ii) (Wave, Wave2, Wave3 all from Model 3; see Analyses section), quadratic for outcomes (iii)-(iv) (Wave, Wave2 both from Model 2; see Analyses section)); where models are not significant (all models for outcome (i), cubic models for outcomes (iii)-(iv)) the results are reported from the corresponding Wave term of that model (i.e., Wave from Model 1, Wave2 from Model 2, Wave3 from Model 3; see Analyses section). The full models including all covariates are shown in Supplementary Table 3.

Figure 1. Timeline of the ITC 4C Survey and tobacco control policies in Canada (CA), US, UK and Australia (AU) between 2001 and 2015.[47]

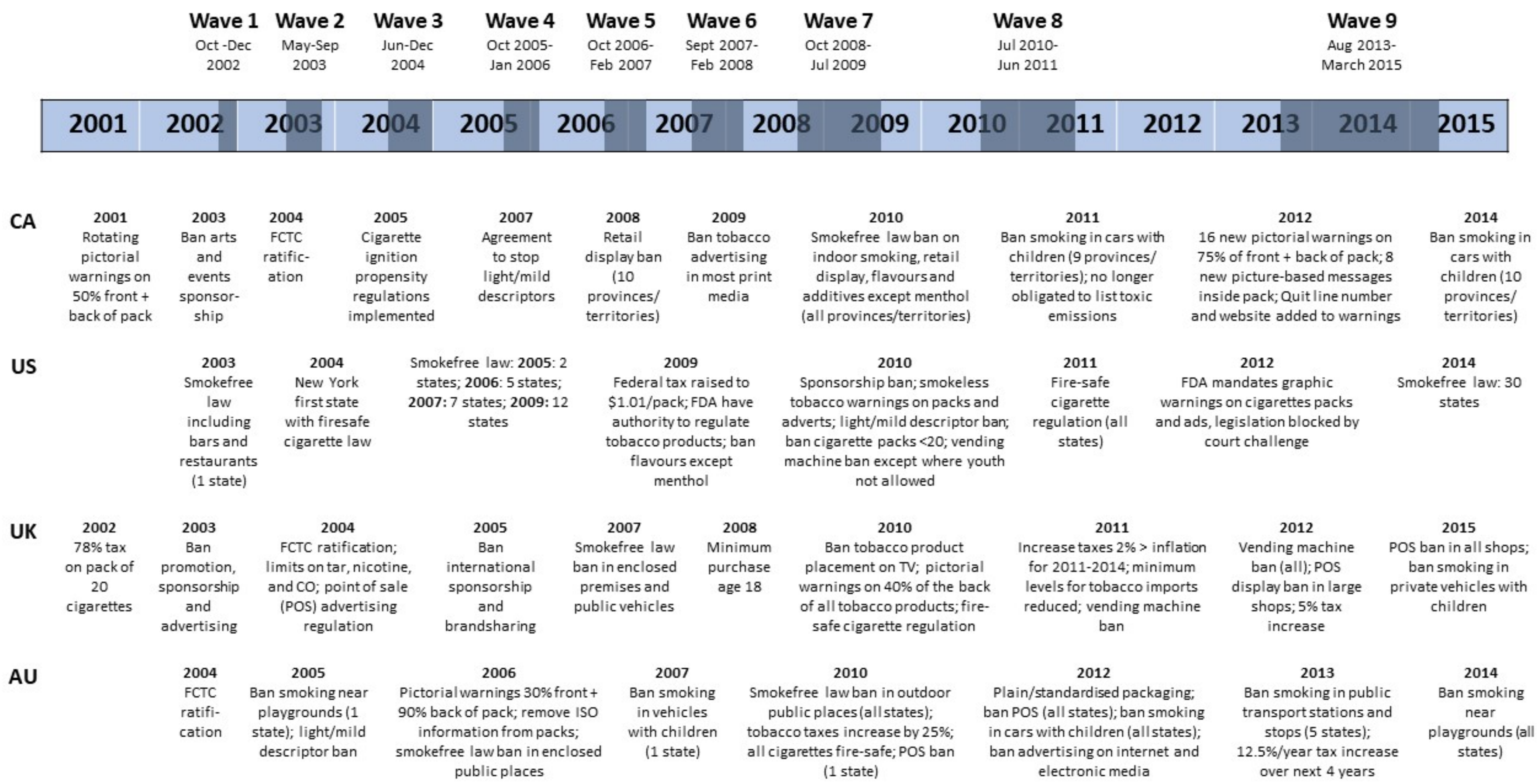
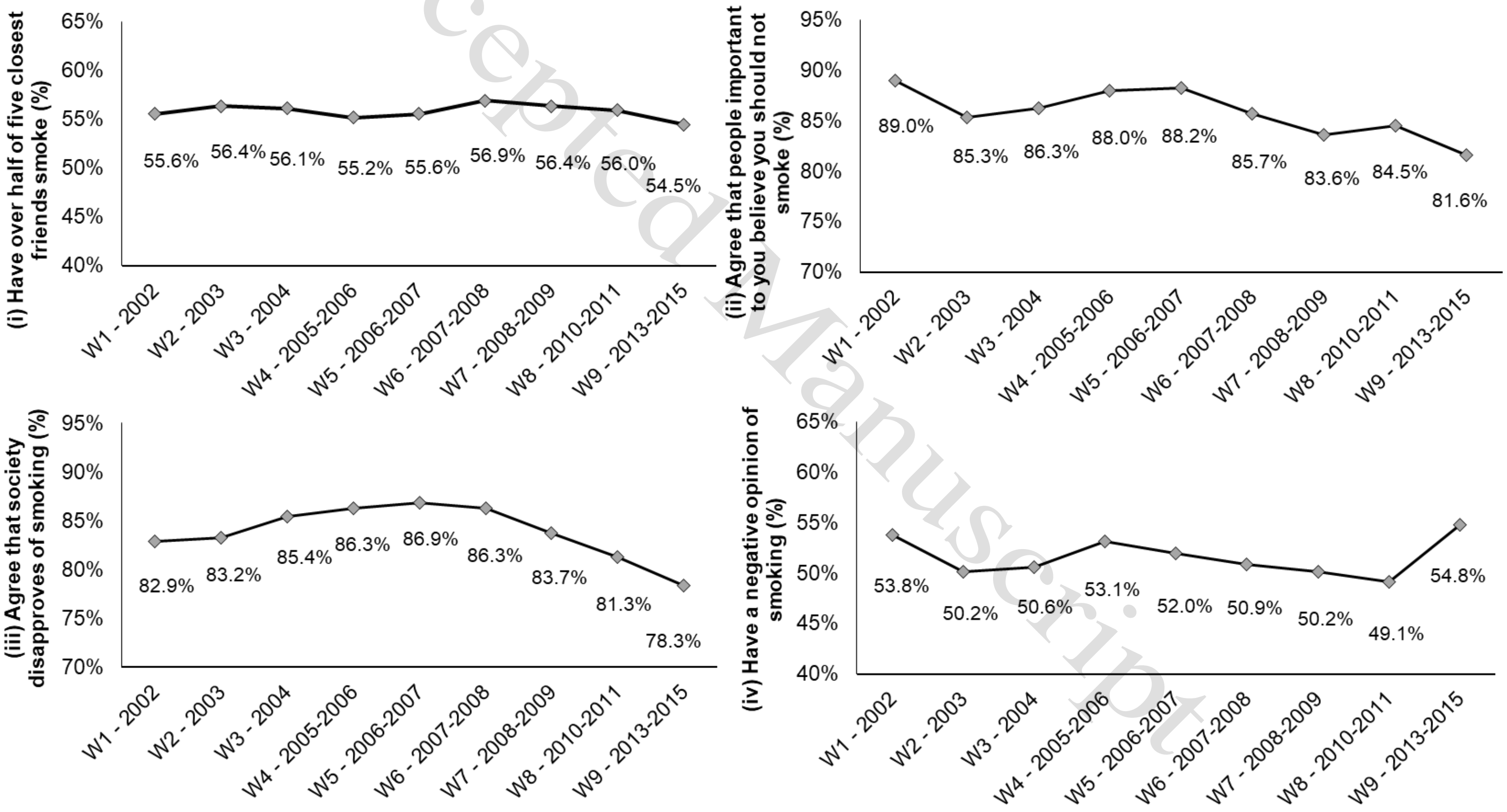


Figure 2. Average predicted probabilities of (i) having over half of five closest friends smoke, (ii) agreeing that people important to you believe you should not smoke, (iii) agreeing that society disapproves of smoking, and (iv) having a negative opinion of smoking, by Wave (N=57,086 observations from 23,831 respondents). Data are from binary logistic regression analyses, adjusted for country, age, gender, ethnicity, income, education, heaviness of smoking, survey mode, time in sample,



8.3. Discussion in relation to this thesis

In my publication above I provided the first assessment of (i) trends in smoking norms and opinions between 2002 and 2015, (ii) differences in smoking norms and opinions across countries, using nationally representative longitudinal data from adult daily smokers from the UK, Canada, the US, and Australia [5]. I found that, among daily smokers, the two injunctive norms (agreeing that people important to you believe you should not smoke and agreeing that society disapproves of smoking) generally decreased between 2002 and 2015, despite increases around 2006-2007 [5]. Friend smoking did not change overall from 2002 to 2015 [5]. Having a negative opinion of smoking decreased between 2002 and 2010-2011, despite increases around 2005-2006 and towards the end of the study (2013-2015) [5]. Except friend smoking, anti-smoking norms and opinions were most common among daily smokers from Canada and least common among daily smokers the UK [5].

As mentioned in my publication above [5], some country differences in daily smokers' injunctive norms and opinions of smoking could be explained to an extent by tobacco control policies and prevalence rates. Consistent with my findings among youth (Chapter 6) [3], I found that daily smokers in Canada had the greatest, and the UK the lowest, anti-smoking injunctive norms and opinions overall [5]. This is consistent with Canada's longer history of tobacco control policies (see Figure 1 in my publication above) and the higher prevalence rates of smoking in the UK [5]. Importantly, early implementation of key tobacco control policies in Canada (Figure 1 in my publication above) may have led to more perceived disapproval over time among both the adult daily smokers in this Chapter [5], and youth in Chapter 6 [3]. However, there was little difference in injunctive norms and opinions of smoking between the UK and US, despite the US generally lagging in the implementation of key tobacco control policies such as national updated health warnings, marketing restrictions, and national smoke-free policy (Figure 1 in my publication above) [5]. Therefore, consistent with my findings from Chapter 6 and Chapter 7, not all country differences in smoking norms could be explained by policies and prevalence rates [3, 4].

Considering the descriptive norm of friend smoking, I found that the proportion of daily smokers who report having over half of five closest friends who smoke was highest in the US [5]. This could be explained by the US having the least comprehensive tobacco control policies (Figure 1 in my publication above) [5]. However, no other country differences or trends in friend smoking corresponded with policies or prevalence rates. Overall, this is inconsistent with my findings among adult smokers in Europe (Chapter 7) [5], which found that this same social norm was more commonly reported in countries with weaker control policies and higher smoking prevalence [4].

Similar to my findings among youth in Chapter 6 and among adult smokers in Europe in Chapter 7 [3, 4], my findings were inconsistent with theories that place norms on the pathway between tobacco control policies and reductions in smoking prevalence [58-62]. My findings were also inconsistent with research that has found smoking to be more denormalised where tobacco control policies are stronger and smoking prevalence is lower [113, 120, 132, 134]. However, my publication above only assessed the changing smoking norms of adult daily smokers who are a unique group [5]. As I discussed in my publication [5], daily smokers are more likely to be of lower socio-economic status, older, and have weaker and potentially more entrenched anti-smoking norms [113, 260-262]. The findings from this Chapter are therefore unlikely to be generalisable to population norms in the UK, Canada, the US, and Australia.

8.3.1. Conclusion

My findings from this Chapter (Chapter 8) do not support the notion that smoking has become denormalised over time among daily smokers from the UK, Canada, the US, and Australia [5]. Instead I found that, between 2002 and 2015, injunctive norms became less anti-smoking despite increases around 2006-2007, friend smoking did not change, and negative opinion of smoking decreased despite increases around 2005-2006 and towards the end of the survey period [5]. Except friend smoking, Canada had the greatest, and UK the lowest, anti-smoking injunctive norms and opinions [5]. Some, but not all, country differences could be explained in part by tobacco control policies and smoking prevalence rates. However, taken together, my findings suggest that the social norms and opinions of daily smokers do not always correspond with tobacco control policies and smoking prevalence. This is similar to my findings among youth in England, Canada, and the US (Chapter 6) [3], and among adult smokers in Europe (Chapter 7) [4], although daily smokers represent a unique group who are likely to have unique smoking norms.

8.4. Impact and dissemination

My publication in Chapter 8 is part of the ITC Project, an international effort to monitor and evaluate key health policies implemented in countries that ratified the Framework Convention on Tobacco Control (FCTC) [5, 60]. My publication therefore forms part of a larger body of evidence evaluating the impact of tobacco control policies on public health.

I presented this work as an oral presentation at the UK Centre for Tobacco and Alcohol Studies (UKCTAS) Ten Year Celebration Conference in Nottingham, England (presentation available online at [11]) and at the Society for the Study of Addiction (SSA) 2018 PhD Symposium in Newcastle, England (presentation available online at [13]). I also presented some of the findings as part of a presentation on smoking and vaping norms to the National Drug and Alcohol Research Centre at The University of New South Wales in Sydney, Australia (presentation available online at [10]). Preliminary findings were also presented by Professor Ron Borland as part of a symposium I organised on social norms as predictors of smoking and vaping at the Society for Research on Nicotine and Tobacco 2018 Annual Meeting in Baltimore, US.

CHAPTER 9

Discussion

The overall aim of this thesis was to explore the associations between smoking and vaping norms and smoking and vaping behaviours and policies. To achieve this, seven specific aims were addressed using six studies. These seven aims were:

To assess, among youth, the associations between:

Aim 1. Smoking norms and smoking behaviours

Aim 2. Vaping norms and vaping behaviours

Aim 3. Vaping norms and smoking behaviours, and smoking norms and vaping behaviours

Aim 4. Vaping initiation and smoking initiation

Aim 5. Smoking and vaping norms and harm perceptions of vaping and nicotine relative to smoking

To assess, among youth, and adult smokers, whether:

Aim 6. Smoking norms correspond with tobacco control policies and smoking prevalence rates

Aim 7. Vaping norms correspond with vaping policies and vaping prevalence rates

In this final Chapter, I highlight my key findings and implications for research and theory for each aim separately. I finish with an overall discussion of the strengths and limitations of my work, implications for policy, and conclusions.

9.1. Aim 1: Among youth, assess the associations between smoking norms and smoking behaviours

I addressed Aim 1 in **Chapter 2** via a systematic review and meta-analysis, in **Chapter 4** using data from a longitudinal survey of British youth age 11-18 [1], and in **Chapter 6** using data from a cross-sectional survey of youth age 16-19 in England, Canada, and the US [3].

9.1.1. Key findings

In my systematic review and meta-analysis in **Chapter 2** I found that, overall, descriptive and injunctive norms towards smoking were predictive of youth smoking initiation. However, not all types of social norm were reliably predictive. The descriptive smoking norms of those in one's close social circle (i.e., family and close friend smoking) had a positive, strong, and reliable effect on youth smoking initiation. Perceived prevalence of smoking among adults had a positive but small effect on youth smoking initiation, while perceived prevalence of smoking among peers had no reliable effect; however, few articles assessed these norms. The injunctive smoking norms of parents and the public, but not friends/peers or people important to you, had a positive and reliable effect on youth smoking initiation in the meta-analysis pooling unadjusted associations. However, findings from the systematic review suggested that when adjusting for covariates, including descriptive norms, few studies found associations between injunctive norms and youth smoking initiation. The associations between norms and youth smoking initiation were also found to vary across countries, being stronger in Asia than the US or Europe.

Using nationally representative longitudinal data from among British youth, in **Chapter 4** I found that having parents who smoke was positively associated with initiating smoking [1], reflecting my findings from Chapter 2. Unlike Chapter 2, I did not find associations between sibling and close friend smoking and youth smoking initiation in adjusted analyses [1]. I also did not find associations between perceived societal approval of smoking and smoking initiation [1]. However, the lack of associations could be attributable to low statistical power because few youth initiated smoking during the study period (n=72/1,152 [6.3%]) [1].

In **Chapter 6** I extended my findings from Chapter 4 to youth across England, Canada, and the US using cross-sectional data [3]. I found that having friends who smoke and perceiving that peers approve of smoking were positively associated with being a current or experimental smoker, compared with a never smoker [3]. There was a strong dose-response association between reporting more friend smoking and greater smoking behaviour that was not mirrored for perceived peer approval [3]. I also found that associations between perceived peer approval of smoking and youth smoking behaviour varied across countries, with evidence of associations in England and the US only [3].

9.1.2. Implications for research and theory

My findings support some previous research and theories [1, 3]. The strong, reliable associations between the smoking behaviour of others within one's close social circle and youth smoking behaviour are consistent with a seminal paper finding that smoking behaviour spreads through groups of interconnected people [95]. They are also consistent with previous reviews finding that family and friend smoking are strong and reliable predictors of youth smoking initiation [96, 97, 99]. They are further consistent with theories such as Social Cognitive Theory and the PRIME (Plans, Responses, Impulses, Motives, Evaluations) Theory of addiction, which propose that the behaviour of others within one's close social circle influence that same behaviour, perhaps more so than wider social groups [58, 73, 76].

Consistent with the findings from a previous meta-analysis [90], my findings also suggested that descriptive norms may be a more reliable predictor of youth smoking behaviour than injunctive norms [1, 3]. The Theory of Planned Behaviour usually measures injunctive norms by assessing perceived approval of smoking among "people important to you" [81, 83, 86-90]. However, inconsistent with previous research [87], I did not find this measure to be consistently associated with youth smoking initiation in my systematic review and meta-analysis (Chapter 2). My findings suggested that recent versions of the Theory of Planned Behaviour that also include the descriptive norms of close others may have greater predictive utility for youth smoking initiation [89, 90].

Prior to initiating my PhD there was little research assessing the associations between social norms at the societal level and youth smoking initiation [99, 101, 103, 104]. My findings suggested that societal-level norms, particularly injunctive norms, may be a less reliable predictor of youth smoking behaviour than some might suppose. However, there is a lack of research in this area and more is needed before any firm conclusions can be drawn.

Consistent with previous research [94], I found that associations between smoking norms and youth smoking behaviour varied across countries. It is possible that the mechanisms through which smoking norms are associated with smoking depends on the tobacco control environment, culture, socio-economic status, or other factors [81, 94, 263]. The understanding of social norms measures may also differ across different cultural and linguistic groups [264], although English was the most common language throughout England, Canada, and the US. Further research is required to understand why the associations between smoking norms and youth smoking behaviour vary across countries.

Finally, it is important to consider why the associations between smoking norms and smoking behaviour emerge. Previous research has found that both socialisation (friends' social norms influence youth smoking) and selection (youth select friends who have similar behaviours and attitudes) both contribute to the association between friends' smoking norms and youth smoking behaviour [97, 98]. The systematic review and meta-analysis in Chapter 2 provides more evidence in support of socialisation effects, because friend smoking was found to precede and predict smoking initiation in several studies [97, 98]. However, socialisation effects could reflect a mixture of influences, such as exposure to social cues, increased opportunities to smoke, copying of behaviour or copying of behaviour that is seen as being rewarded, or desires to conform or cooperate with behaviours and attitudes of a social group [64, 73, 76, 77]. Qualitative research or more nuanced measures of social norms are required to understand why these associations emerge, and to help to advance behavioural theories.

9.2. Aim 2: Among youth, assess the associations between vaping norms and vaping behaviours

I addressed Aim 2 in **Chapter 4** using data from a longitudinal survey of British youth age 11-18 [1] and in **Chapter 6** using data from a cross-sectional survey of youth age 16-19 in England, Canada, and the US [3].

9.2.1. Key findings

In **Chapter 4** I presented and discussed the first study to assess the longitudinal associations between vaping norms and vaping initiation among British youth [1]. I found that having friends who vape was positively associated with initiating vaping [1]. I did not find associations between parent and sibling vaping and youth vaping initiation in adjusted analyses [1]. I also did not find associations between perceived societal approval of vaping and youth vaping initiation, similar to my findings for smoking [1]. However, as above, the lack of associations could be attributable to low statistical power because few youth initiated vaping during the study period (n=72/923 [7.8.%]) [1].

In **Chapter 6** I extended my findings from Chapter 4 to youth across England, Canada, and the US using cross-sectional data [3]. Similar to Chapter 4 [1], in Chapter 6 I found that having friends who vape was positively associated with being a current, experimental, or former vaper compared with a never vaper [3]. Perceiving that peers approve of vaping was also positively associated with being a current, experimental, or former vaper [3]. Similar to my findings for smoking norms, I found a strong dose-response association between friend vaping and vaping behaviour that was not mirrored for perceived peer approval [3]. I also found that the strength of associations between vaping norms and youth vaping behaviour varied across countries [3].

9.2.2. Implications for research and theory

Prior to starting my PhD, little was known about the social norms surrounding vaping. Consistent with my findings [1, 3], some cross-sectional studies had found that youth with friends who vape are more susceptible to, and more likely to try, vaping [136, 137, 166]. Friends' vaping, like friends' smoking, may therefore be a reliable predictor of product use. My longitudinal results from Chapter 4 further suggested that friend vaping can precede and predict vaping initiation [1], again reflecting my findings for smoking (Section 9.1). These longitudinal results support the notion of socialisation (friends' social norms influence youth smoking) more so than selection (youth select friends who have similar behaviours and attitudes) [1, 97, 98]. Socialisation effects have also been found for smoking [97, 98], but not previously for vaping, although further research is needed to replicate my findings.

Previous cross-sectional studies among youth had also found that perceiving societal approval of vaping was associated with being susceptible to vaping and being a current vaper [15, 136]. My longitudinal findings from Chapter 4 are inconsistent with these studies [1], although my cross-sectional findings from Chapter 6 suggested that perceiving *peer* approval of vaping was associated with vaping behaviour, but to a lesser extent than friend vaping [3]. Again, this reflects my findings for smoking and may suggested that friends' smoking is a more reliable predictor of vaping behaviour than the perceived approval of wider social groups.

Vaping norms were also found to have different associations with vaping behaviour across countries. This is consistent with my findings for smoking, but to my knowledge country differences in norms towards vaping had not been assessed among youth prior to my PhD. Potential reasons for differences in the associations between norms and behaviours across countries are discussed in Section 9.1.2 above.

My results were again consistent with Social Cognitive Theory and PRIME Theory, which emphasise the importance of the descriptive norms of close others in predicting behaviour [58, 73, 76]. However, as mentioned in Section 9.1.2

above, the associations between norms and behaviours could emerge because of a variety of influences. It is important that vaping norms are continued to be studied given the lack of research in this area.

9.3. Aim 3: Among youth, assess the associations between vaping norms and smoking behaviours, and smoking norms and vaping behaviours

I addressed Aim 3 in **Chapter 4** using data from a longitudinal survey of British youth age 11-18 [1] and in **Chapter 6** using data from a cross-sectional survey of youth age 16-19 in England, Canada, and the US [3].

9.3.1. Key findings

In **Chapter 4** I presented and discussed the first study to assess the longitudinal associations between vaping norms and smoking initiation, and smoking norms and vaping initiation, among British youth [1]. I found that friend vaping was strongly protective against youth smoking initiation, while perceiving that the public approve of smoking was protective against youth vaping initiation [1]. I did not find associations between parent and sibling vaping and youth smoking initiation, or between friend, parent, and sibling smoking and youth vaping initiation, in adjusted analyses [1]. I also did not find an association between perceiving public approval of vaping and smoking initiation [1]. However, as mentioned above, the lack of associations could be because of low power.

My findings from **Chapter 6**, which used cross-sectional data from among youth in England, Canada and the US [3], were somewhat different from Chapter 4 [1]. Inconsistent with Chapter 4, I found that friend vaping was positively associated with being an experimental smoker compared with a never smoker [3]. However, I also found that perceiving that peers approve of vaping was negatively associated with being an experimental or current smoker compared with a never smoker [3]. Friend smoking and also perceiving that peers approve of smoking were positively associated with being an experimental vaper compared with a never vaper [3]. I also found that associations varied across countries: friend vaping was positively associated with smoking in the US, perceiving that peers approve of vaping was negatively associated with smoking in England and Canada, and perceiving that peers approve of smoking was positively associated with vaping in England and Canada [3].

9.3.2. Implications for research and theory

To my knowledge, prior to starting my PhD there had been no longitudinal studies exploring the associations between vaping norms and smoking behaviour, or smoking norms and vaping behaviour, among youth. As stated in the Introduction of this thesis (Section 1.4.6), because of the similarities between vaping and smoking it is possible that norms towards one product predict use of the other. Of specific concern is that vaping could renormalise and increase smoking among youth [35, 48, 51-56]. Specifically, observation of others engaging in, or approving of, a behaviour somewhat similar to smoking could encourage smoking among youth [15, 50, 55, 56]. However, it is also possible that vaping could further denormalise and accelerate declines in smoking.

Inconsistent with claims that that others' vaping could encourage youth smoking [15, 50, 55, 56], in Great Britain (Chapter 4) and England only (Chapter 6) I found that overall more positive norms towards vaping were protective against youth smoking [1, 3]. On the contrary, consistent with renormalisation concerns [15, 50, 55, 56] and with previous research [56], I found that friend vaping was positively associated with smoking among US youth in Chapter 6 [3]. Vaping could thus have the potential to renormalise, or denormalise, smoking among youth. However, additional longitudinal research is required to replicate my findings and explore why these associations emerge, before any firm conclusions can be drawn. Research exploring associations between smoking norms and vaping norms could also aid interpretation of my findings.

Considering the associations between smoking norms and youth vaping behaviour, again the direction of associations was mixed. My cross-sectional findings from Chapter 6 [3] were consistent with previous cross-sectional research, which has found that friend smoking is positively associated with youth vaping behaviour and susceptibility to vaping [15, 136, 159, 166]. However, in longitudinal analyses I found that perceiving that the public approve of smoking was *protective against* vaping initiation in longitudinal analyses (Chapter 4) while in cross-sectional analyses I found that perceiving that peers approve of smoking was *positively associated* with vaping in the US (Chapter 6) [1, 3]. As above, additional longitudinal research is required to understand why these associations emerge.

Interestingly, in Chapter 6 I found that experimental smokers reported greater friend vaping (a descriptive norm) but less peer approval of vaping (an injunctive norm) than never smokers [3]. Consistent with previous research [89, 90], my findings again highlight the importance of assessing descriptive and injunctive norms separately among different social groups. Associations between descriptive norms and a behaviour and injunctive norms and that same behaviour may show opposite effects.

I also found that the direction of associations between vaping norms and smoking behaviour varied across countries [3]. This is consistent with other findings from my thesis. Potential reasons for differences in the associations between norms and behaviours across countries are discussed in Section 9.1.2 above.

It is important to note that in Chapter 4 and Chapter 6 I adjusted for different covariates, which may have led to different results. In Chapter 4, smoking and vaping norms were treated as predictors, while in Chapter 6 smoking and vaping norms were treated as outcomes. Therefore, in Chapter 4 I included both friend smoking and friend vaping simultaneously in models [1], while I did not in Chapter 6 [3]. It is likely that social norms towards one product confounds social norms towards the other. For example, friends who vape may also smoke or be ex-smokers. Future studies should explore the effect of having friends who concurrently smoke and vape, use either product exclusively, or have switched from smoking to vaping, on youth smoking and vaping behaviours. Other potential reasons for the different findings between Chapter 4 and Chapter 6 include study design (longitudinal vs. cross-sectional), age of the sample (11-18 vs. 16-19), country (as found in Chapter 2 and Chapter 6 [3]), and smoking and vaping status of the sample (never smokers/never vapers vs. all youth).

9.4. Aim 4: Among youth, assess the associations between vaping initiation and smoking initiation

I addressed Aim 4 in **Chapter 4** using data from a longitudinal survey of British youth age 11-18 [1].

9.4.1. Key findings

In **Chapter 4** I presented and discussed the first nationally representative study among British youth to assess the longitudinal associations between vaping and smoking initiation, and smoking and vaping initiation [1]. Compared with youth who had never vaped, I found that youth who tried vaping had greater odds of progressing to trying smoking [1]. Compared with youth who had never smoked, I also found that youth who tried smoking had greater odds of progressing to trying vaping [1]. I confirmed these associations via causal mediation analyses [1]. Overall there were very few never smokers who had tried vaping (21 out of 923 youth [2.3%]) [1].

9.4.2. Implications for research and theory

My findings add to the growing body of evidence that vaping among never smoking youth is associated with subsequent smoking initiation [146-157]. My findings were also consistent with studies that have found that trying smoking was associated with subsequently initiating vaping [154, 159]. Taken together, my findings suggested that the associations between vaping and smoking initiation among youth might work both ways. Further, my use of causal mediation analyses allowed for stronger conclusions to be made than standard logistic regression models regarding the associations between both products [265].

The longitudinal association between trying vaping and initiating smoking has been interpreted as a "gateway" effect by some academics [48, 49, 51, 52]. Specifically, e-cigarettes have been theorised to attract non-smoking individuals, particularly youth, into nicotine use and subsequent smoking [35, 48-51]. However, this interpretation has been contested by Kozlowski and Warner, who state that there may be underlying predispositions or risk factors for both vaping and smoking that drive both behaviours [158]. Further, my findings suggested that the association between vaping and smoking initiation works both ways. Additional research is required to understand the mechanisms linking vaping and smoking. Specifically, multi-wave longitudinal surveys or birth cohort studies could be used to explore the dynamic changes in use of both products over time while measuring underlying predispositions and risk factors.

It is still unclear whether vaping can predict smoking that is maintained over long periods of time. Similar to most previous research in this field [146-151, 153, 154], my publication in Chapter 4 used outcomes of smoking and vaping initiation defined as progressing from never to ever use (even a puff) because of low numbers of regular smokers and regular vapers [1]. A meta-analysis found that over two thirds of individuals who try smoking go on to become, at least temporarily, daily smokers [266]. Further, some studies in this area have also found that vaping predicts progression to regular smoking (smoking at least one cigarette a week) and past-month smoking [151, 155]. Despite this, it is unclear whether such regular smoking is maintained over time, which would be more problematic for public health than experimentation or regular smoking that is short-lived. Longitudinal studies over longer periods of time and with large samples are required to assess whether youth vaping and smoking behaviours are maintained.

9.5. Aim 5: Among youth, assess the associations between smoking and vaping norms and harm perceptions of vaping and nicotine relative to smoking

I addressed Aim 5 in **Chapter 5** using data from a cross-sectional survey of British youth age 11-18 [2].

9.5.1. Key findings

In **Chapter 5** I presented and discussed the first nationally representative study among British youth to explore the associations between smoking and vaping norms and the harm perceptions of vaping and nicotine relative to smoking [2]. I found that most youth (63%) accurately perceived vaping as less harmful than smoking, while very few (9%) accurately perceived that none or a small amount of the harm from smoking comes from nicotine [2]. I also found that having family members who vape and perceiving that the public approve of vaping but disapprove of smoking were positively associated with accurately perceiving that vaping is less harmful than smoking [2]. Having family members who smoke was positively associated with accurately perceiving that none or a small amount of the harm from smoking come from nicotine [2].

9.5.2. Implications for research and theory

My findings [2] were somewhat consistent with the Health Belief Model, which proposes that social factors help to shape perceptions of risk surrounding a behaviour, which in turn drives behaviour itself [81, 168]. However, my findings were cross-sectional and cannot determine the direction of associations [2]. Future longitudinal studies are required to understand the mechanisms through which associations between smoking and vaping norms and harm perceptions of vaping and nicotine occur.

Interestingly, I found that accurate harm perceptions of vaping were *positively* associated with perceiving that the public approve of vaping but *negatively* associated with perceiving that the public approve of smoking [2]. It is possible that increased awareness of a less harmful alternative to smoking could counteract or reduce how approved of smoking is perceived to be, thus contributing towards the denormalisation of smoking. However, this is only speculation, and, as mentioned above, cross-sectional data make it difficult to determine the direction of associations. Future research should explore the longitudinal associations between harm perceptions of vaping and smoking and vaping norms to assess this claim, and to further assess whether changing harm perceptions of vaping could change social norms surrounding both vaping and smoking.

9.6. Aim 6: Among youth, and adult smokers, assess whether smoking norms correspond with tobacco control policies and smoking prevalence rates

I addressed Aim 6 in **Chapter 6** using data from a cross-sectional survey of youth age 16-19 in England, Canada, and the US [3], in **Chapter 7** using data from a cross-sectional survey of adult smokers in seven European countries [4], and in **Chapter 8** using data from a longitudinal survey of adult daily smokers in the UK, Canada, the US, and Australia [5].

9.6.1. Key findings

In **Chapter 6** I presented and discussed the first study to assess differences in smoking norms across countries (England, Canada, US) among *youth*, using cross-sectional data [3]. I found that English youth reported more friend smoking and peer approval of smoking than both Canada and the US. However, at the time of surveying, the US had the least comprehensive tobacco control policies, and England and the US both had the highest smoking prevalence rates among youth. These findings suggested that smoking norms may not always correspond with strength of tobacco control policies and smoking prevalence rates.

In **Chapter 7** I extended my findings from Chapter 6 [3] to assess differences in smoking norms among *adult smokers* across seven European countries, using cross-sectional data [4]. Overall, I found that friend smoking was more common among adult smokers from countries with weaker tobacco control policies and greater smoking prevalence rates. On the contrary, except England, I found that injunctive smoking norms did not correspond with tobacco control policies and smoking prevalence rates. I also found that, except England, perceiving that smokers are marginalised was more common among adult smokers from countries with greater smoking prevalence rates, but did not correspond with strength of tobacco control policies.

I further extended my findings from Chapter 6 [3] and Chapter 7 [4] in **Chapter 8**. In Chapter 8, I provided the first longitudinal assessment of trends and country differences in smoking norms and opinions among *adult daily smokers* from the

UK, Canada, the US, and Australia [5]. Overall, I found that, between 2002 and 2015, daily smokers' perceptions that people important to them believe they should not smoke and that the public disapprove of smoking decreased, despite increases around 2006-2007. I also found that, among daily smokers, friend smoking did not change between 2002 and 2015, and negative opinion of smoking decreased despite increases around 2005-2006 and 2013-2015. These trends do not support the notion that smoking has become denormalised over time among adult daily smokers. Somewhat consistent with strength of tobacco control policies, I found that daily smokers from Canada had the greatest anti-smoking injunctive norms and opinions. However, other country differences generally did not correspond with tobacco control policies or smoking prevalence rates. It is important to note that adult daily smokers are a unique group. These trends and country differences in smoking norms therefore may not generalise to the general populations of adults, or youth, in the UK, Canada, US, and Australia.

9.6.2. Implications for research and theory

My findings were broadly inconsistent with conceptual models and theories that place social norms on the pathway between tobacco control policies and changes in smoking prevalence [58-62]. My findings were also broadly inconsistent with previous research finding that smoking is less common and approved of in US communities with stronger tobacco control policies [120], and with recent research finding that the proportion of British youth who perceive smoking as "OK" has decreased between 1998 and 2015 [134]. However, my results did complement a previous study among adult smokers in UK, Canada, the US, and Australia, which found that reporting societal disapproval of smoking as a reason for quitting did not show any clear increases between 2002 and 2015 overall [135]. Associations between smoking norms and tobacco control policies and prevalence rates may therefore be more complex than initially theorised, at least among adult smokers and youth.

One finding was consistent with theories [58-62]: in Chapter 7 I found that close friend smoking was lower among adult smokers from European countries with stronger tobacco control policies and lower smoking prevalence rates [4]. This finding supports my earlier findings by suggesting that the descriptive norms of close others may be a better measure of social norms than other measures if the aim is to predict declines in smoking. However, close friend smoking did not correspond with tobacco control policies or smoking prevalence rates among the youth assessed in Chapter 6 or the adult daily smokers assessed in Chapter 8 [3, 5].

There are several possible explanations for the overall lack of correspondence between smoking norms and tobacco control policies and smoking prevalence rates that I found among adult smokers and youth. These explanations are discussed in detail in my publications in Chapters 6-8 [3-5]. Perhaps the most plausible explanation is that increasingly comprehensive tobacco control policies and decreasing smoking prevalence could have led individuals, including both adult smokers and youth, to perceive *less* disapproval, or at least no more disapproval, of smoking because of reduced exposure to smoking, particularly in public places (i.e., “out of sight, out of mind”). Policies limiting smoking in public places might also lead to smokers, particularly daily smokers, having reduced opportunities to smoke and perceiving less disapproval from those around them. However, this proposition would be difficult to assess and does not explain the lack of correspondence between descriptive smoking norms and tobacco control policies and smoking prevalence rates. Future research in this area could consider using more nuanced measures of social norms, for example asking why individuals perceive approval or disapproval of smoking from different social groups.

My findings are unlikely to be generalisable to population norms towards smoking. As discussed Sections 8.2 and 8.3 above, daily smokers, and also smokers in general, likely have unique smoking norms. Social norms among youth are also unlikely to generalise to adults. Further research using ongoing nationally representative longitudinal surveys, such as the US Population Assessment of Tobacco and Health (PATH) Surveys [267], should be used to extend my findings to both youth and adults, including smokers, non-smokers, and those who quit smoking.

Finally, among the adult smokers assessed in Chapters 7-8, both country differences and trends in descriptive norms towards smoking did not correspond with the country differences and trends in injunctive norms towards smoking [4, 5]. These findings reflect those found throughout this thesis and also previous research: that descriptive and injunctive norms are different constructs [89, 90], and may not always correspond with one another.

9.7. Aim 7: Among youth, and adult smokers, assess whether vaping norms correspond with vaping policies and vaping prevalence rates

I addressed Aim 7 in **Chapter 6** using data from a cross-sectional survey of youth age 16-19 in England, Canada, and the US [3] and in **Chapter 7** using data from a cross-sectional survey of adult smokers in seven European countries [4].

9.7.1. Key findings

In **Chapter 6** I presented and discussed the first study to assess differences in vaping norms across countries (England, Canada, US) among *youth*, using cross-sectional data [3]. At the time of surveying, Canada had the most restrictive vaping policies and lowest prevalence of youth vaping of the three countries. Contrary to strength of vaping policies and vaping prevalence rates, I found that friend vaping and perceived peer approval of vaping were most commonly reported among Canadian youth and least commonly reported among English youth [3].

In **Chapter 7** I extended my findings from Chapter 6 [3] to assess differences in vaping norms among *adult smokers* across seven European countries, also using cross-sectional data [4]. Overall, I found that seeing vaping in public was more common among adult smokers from countries with greater vaping prevalence rates, but reporting of friend vaping and perceived public approval of vaping did not correspond with vaping prevalence rates [4]. Overall, my results suggested that vaping norms do not always correspond with country-level prevalence rates of vaping.

9.7.2. Implications for research and theory

To my knowledge, prior to my PhD vaping norms had not been explored across countries among youth, or across European countries among adult smokers. My findings were similar to my findings for smoking norms (Section 9.6 above). My findings were also broadly inconsistent with conceptual models and theories that place social norms on the pathway between policies and changes in prevalence [58-62] and with previous research that I was involved in during my PhD [138].

Consistent with previous research [138], I found that one vaping norm did correspond with vaping prevalence among adult smokers from Europe (Chapter 7): seeing vaping in public at least some days was more commonly reported among those from countries with higher vaping prevalence rates [4]. This finding was unsurprising and similar to my findings for smoking [4], to the extent that descriptive norms corresponded with policies and prevalence rates. However, I did not find that friend vaping (also a descriptive norm) corresponded with vaping prevalence rates in Chapter 7 [4] or among youth in Chapter 6 [3].

Similar to my findings for smoking (Section 9.6 above), I found that country differences in seeing vaping in public at least some days did not correspond with country differences in perceiving that the public approve of vaping among adult smokers in Europe (Chapter 7) [4]. Descriptive and injunctive norms towards vaping may therefore not always correspond with one another, consistent with previous research suggesting that descriptive and injunctive norms are different constructs [89, 90]. Moreover, Aleyan et al. [138] found that country differences in vaping norms were less pronounced for injunctive than descriptive norms, also somewhat consistent with my findings [4].

It is important to consider that any associations between vaping norms and vaping prevalence rates may be confounded by smoking prevalence rates, particularly among adult smokers [4]. For example, in Europe some public health bodies have encouraged smokers to switch to vaping because of the health benefits, and e-cigarettes are often used as an aid to smoking cessation [27, 38, 257, 268]. Therefore, individuals from countries with higher smoking prevalence rates may perceive greater approval of vaping irrespective of vaping prevalence rates. Indeed, among the adult smokers in Chapter 7, perceived public approval of vaping was most common in Greece and Poland, where smoking prevalence was highest [4]. Future research should consider country-level differences in smoking and vaping prevalence rates, or interactions between smoking and vaping prevalence rates, when exploring vaping norms.

Similarly, tobacco control policies may confound associations between vaping norms and vaping policies. For example, individuals from countries with stronger tobacco control policies may perceive greater approval of vaping because vaping offers an alternative method of nicotine consumption which might be more affordable (in countries that heavily tax tobacco products), able to be used more widely (in countries with more comprehensive smoke-free policies), and is less harmful than smoking [269]. Future research in this area should also consider differences in tobacco control and vaping policies and possible interactions between them.

Avenues for future research also include assessing changes in vaping norms, and smoking norms, following the implementation of new vaping policies. For example, Canada implemented a new Vaping Products Act in 2018, relaxing many vaping restrictions and approving the sale of nicotine-containing e-cigarettes to persons over the age of 18 [270]. Assessing changes in vaping norms before and after implementation of this new Act, compared to England where policies remained relatively stable in 2018, could aid interpretation of my findings.

9.8. Strengths and limitations of this research

The main strength of this thesis lies in its integration of existing work (Chapter 2) and national and international data from youth, and adult smokers (Chapters 4-8) to produce what is likely some of the most comprehensive work to date on the associations between smoking and vaping norms, behaviours, and policies [1-5]. Specific methodological strengths and limitations of the work in this thesis are listed below.

9.8.1. Strengths

9.8.1.1. Generalisability

Chapters 4-5 used data from nationally representative samples of British youth [1, 2]. Chapters 7-8 used data from nationally representative samples of adult smokers across ten countries [4, 5]. Data in Chapters 4-8 were also weighted to enhance the generalisability of the findings to the populations from which the samples were derived [1-5]. The use of ten countries surveyed across Chapters 4-8 also enhances the generalisability of my findings to youth from Great Britain and North America, and to adult smokers from North America, Australia, and much of Europe [1-5].

9.8.1.2. Sample size

The samples used across Chapters 4-8 were large, between 1,152 respondents (Chapter 4) and 23,831 respondents (Chapter 8). This enhances statistical power and confidence in my findings [1-5].

9.8.1.3. Use of longitudinal data

Chapter 2, Chapter 4, and Chapter 8 involved the use of longitudinal data [1, 5], which allowed for prospective assessment of associations between norms and behaviour, and also trends in norms over time. The use of longitudinal data allows stronger conclusions to be made regarding the direction of associations, for example whether social norms influence youth smoking or vice-versa.

9.8.1.4. Measures of social norms towards smoking and vaping

Chapters 4-7 [1-4] used measures of social norms that had been validated in my previous work via cognitive interviewing and pilot survey testing [15]. Moreover, self-reported perceptions of others' smoking have been found to be reliable and valid [271-274] and studies have found that the perceived smoking behaviours of others is a stronger predictor of smoking than the actual smoking behaviours of others [78-80].

9.8.1.5. Causal mediation analyses

In **Chapter 4** I used a novel causal inference approach, causal mediation analyses, to assess the associations between vaping and smoking initiation, and smoking and vaping initiation [1]. To my knowledge, these analyses had not been used previously to assess these associations. Causal mediation analyses go beyond standard regression models by disentangling different pathways that could explain the effect of an exposure (e.g., vaping) on an outcome (e.g., smoking initiation) [265]. Further, causal mediation analyses can quantify reliable direct and indirect causal effects for binary variables, and produces narrow confidence intervals to allow for stronger conclusions to be made regarding observed associations [265]. My results therefore provided further, stronger, support for the associations between vaping and smoking initiation, and smoking and vaping initiation, among youth [1].

9.8.2. Limitations

9.8.2.1. Generalisability

My samples only consisted of youth, and adult smokers, from countries that have developed economies and largely anti-smoking policies [1-5]. My findings are unlikely to be generalisable to the general populations of adults in each country assessed. My findings are also unlikely to be generalisable to low- and middle-income countries, or to countries at earlier stages of the tobacco epidemic. Future studies should explore smoking and vaping norms, including their associations with smoking and vaping behaviours and policies, across a broader range of countries at national population levels.

My findings may also not be generalisable to more recent years. Since the data used in this thesis were collected, the vaping environments have changed in many countries. For example, Canada relaxed many vaping restrictions in 2018 [270], while some jurisdictions in the US have proposed banning vaping [275]. It is also uncertain how the tobacco and nicotine landscapes will evolve in the coming years. Continuing to monitor norms alongside these changing environments could help to understand associations between changing tobacco control and vaping policies and norms.

9.8.2.2. Use of cross-sectional data

In Chapters 5-7 I reported on the use of cross-sectional data [2, 3]. Cross-sectional data cannot determine the directions of associations between norms and behaviour. For example, associations between social norms and behaviours could emerge because behaviours influence norms, or because norms influence behaviour. However, in Chapter 2 and Chapter 4 I did assess the longitudinal associations between norms and behaviour; these Chapters thus aid the interpretation of my cross-sectional findings [1]. In Chapter 8 I also used longitudinal data to assess how smoking norms have changed over time among adult daily smokers [5], to extend my cross-sectional findings from Chapters 6 and 7 [3, 4].

9.8.2.3. Use of different survey methodologies

The survey data used in this thesis were derived using different methodologies [1-5]. The surveys I used in Chapters 4-6 were all online [1-3], those used in Chapter 7 were household surveys [4], while those used in Chapter 8 were a combination of telephone and online surveys [5]. These differences may make my findings difficult to compare across Chapters.

9.8.2.4. Measures

9.8.2.4.1. Differences in measures across surveys

In Chapters 4-8 there were differences across surveys in the measures used and the wording of measures [1-5]. Where possible, I selected consistent measures of social norms to enhance comparability. However, this was not always possible because of survey resource constraints and because wording often changed as a result of discussions with the different research teams and survey firms. These differences must be considered when interpreting similarities and consistencies across Chapters.

9.8.2.4.2. Social norms towards smoking and vaping

In all of Chapters 4-8, I dichotomised the social norms measures (e.g., over half vs. under half of five closest friends smoke, the public approves vs. does not approve of smoking) [1-5]. Treating social norms as continuous, such as assessing the average number of smoking/vaping friends or the degree of perceived approval of smoking, may have shown different associations with smoking and vaping behaviours and policies. Despite this, social norms towards smoking and vaping are often dichotomised [99, 102, 104, 136, 138, 146, 206, 207]. This allows for comparison of my results with other studies.

The social norms measures I selected to use in Chapters 4-8 did not consider the salience of norms [1-5]. It has been argued that social norms will only predict an individual's behaviour if they are important to that same individual, or if individuals have a motivation to comply with that norm [63, 66]. Lack of associations found between social norms and smoking and vaping behaviours, harm perceptions, and policies and prevalence rates could therefore be attributable to lack of salience. Moreover, this could explain why I found that the descriptive norms of close others (whose behaviours are likely to be more salient) were more reliably associated with youth smoking behaviour than the descriptive norms of wider social groups.

The social norms measures I selected to use in Chapters 4-8 were all treated as single-item [1-5]. Multi-item measures of injunctive social norms (e.g., "My friends/best friend/family/people important to me think I should/should not smoke") have been found to be stronger predictors of intention to engage in a behaviour than single-item measures (e.g., "people important to me think I should/should not smoke") [84]. Lack of associations could therefore also be attributable to the use of single-item measures. However, my findings highlight the importance of considering the norms of different social groups separately, rather than combining them, because they can be differentially associated with smoking.

9.8.2.4.3. Smoking and vaping behaviours

The measures of smoking and vaping behaviours in Chapter 2 and Chapters 4-8 were all entirely self-report, except some smoking outcomes in the systematic review in Chapter 2 [1-5].[5] Self-report measures may be subject to recall or social desirability biases, the former of which may be particularly pronounced when asking youth about their smoking and vaping behaviours. However, self-reports of smoking have been found to be reliable and valid [271-274].

9.8.2.5. Moderation and confounding

While the studies included in this thesis did assess several covariates (see Section 3.4 above) there remains several potential moderators of the associations between smoking and vaping norms and behaviours, harm perceptions, and policies and prevalence rates that were not accounted for. Factors relating to the individual (e.g., personality, self-efficacy, attitudes, culture), the social norm (e.g., salience, temporal stability), and the behaviour (e.g., anticipated regret, previous experience of the behaviour, perceived accessibility) have all been found to moderate associations between norms and behaviour [81, 82, 87-90, 263, 276-279]. Specifically, friends' approval of smoking has been found to interact with smoking attitudes and self-efficacy to resist smoking when predicting youth smoking [218]. Associations between peer smoking and smoking initiation have also been found to be stronger among youth who have greater perceived accessibility of cigarettes. [211]. Vaping norms might be subject to moderation in similar ways.

Associations between smoking and vaping norms and behaviours may also emerge because of confounders. Associations between parent and sibling smoking and youth smoking behaviour are likely, at least in part, to be attributable to genetics or shared environments [280]. Further, the socio-economic status, problem behaviour, rebelliousness, alcohol use, or other drug use within a social group could influence both social norms towards smoking and vaping, and also smoking and vaping behaviour. Studies using genetic analyses,

[5] Five studies included in the systematic review reported in Chapter 2 bio-verified smoking status.

and studies measuring a range of peer-group risk factors, might help address these concerns.

9.9. Overall implications for policy

9.9.1. Implications for tobacco control policies

Prevention of smoking initiation is a priority for tobacco control efforts because smoking is an addictive and hazardous behaviour that puts individuals at risk of a lifetime of ill-health [16]. Norms, particularly from within one's close social circle, may be modifiable risk factors for behaviour. Further, some interventions and population-level policies focus on denormalising smoking as a means of reducing smoking prevalence [57, 105-109].

My findings suggested that the descriptive norms of close others (i.e., family and friend smoking) have a strong and reliable influence on youth smoking initiation, perhaps more so than the injunctive norms of close others or the norms of wider social groups. Policies should continue to prioritise reducing smoking prevalence, specifically encouraging parents who smoke to quit, and reducing youth exposure to smoking in the home and among friends. Policies that focus on reducing how common smoking is perceived to be among peers or society, or that focus on reducing the perceived acceptability of smoking, may be less effective in reducing youth smoking.

Some tobacco industry funded campaigns, such as Philip Morris International's 1996-2006 "Talk. They'll Listen" and 2003-2005 "Raising Kids Who Don't Smoke" campaigns [281] have encouraged parents who smoke to talk to their children about not smoking, rather than emphasising the importance of parents quitting. My findings suggested that parent smoking is a strong and reliable predictor of smoking initiation, more so than parents' attitudes, and that the effect of parent attitudes may be redundant to parents' actual smoking behaviour. These campaigns may therefore reflect another ineffective industry-funded youth smoking prevention programme [282, 283].

Declines in youth perceptions of the proportion of peers who smoke have previously been used as indicators of the denormalisation of smoking and reductions in youth smoking prevalence [114]. However, my findings suggested that perceived peer smoking prevalence may not have a reliable influence on youth smoking initiation. Instead, perceptions of smoking among close friends could be used to predict reductions in youth smoking.

I also found that social norms towards smoking, particularly injunctive norms, do not always correspond with tobacco control policies and smoking prevalence rates among adult smokers and youth [3-5]. Tobacco control policies are likely to have a direct effect on reducing smoking initiation and promoting quitting that occur irrespective of changes in smoking norms. For example, smoke-free legislation [124-127], greater expenditure on anti-tobacco mass media campaigns [121-123], and point-of-sale display bans [128] have all been found to directly promote quitting and reduce smoking prevalence. Moreover, while I found no change in close friend smoking and an overall decrease in anti-smoking injunctive norms among adult daily smokers between 2002-2015 [5], smoking prevalence had declined alongside increasingly comprehensive tobacco control policies in the four countries assessed (UK, Canada, US, Australia) [131]. This may question whether smoking denormalisation is a valid approach to tobacco control, at least to the extent that denormalisation is conceptualised as a reduction in how common and approved of smoking is perceived to be. At the very least, my findings suggest that smoking denormalisation among adult smokers and youth is more complex than initially theorised. However, as mentioned previously, further research is required to extend my findings across general populations of adults and youth over time.

9.9.2. Implications for e-cigarette policies

The relative public health impact of e-cigarettes is unknown and policy implications for vaping are therefore more complex than for smoking. My findings from this thesis provided important insights. However, my findings must be considered tentative until further research identifies the mechanisms through which vaping and smoking norms, behaviours, and policies are related.

Of primary concern to public health is the possibility that vaping could renormalise and increase smoking, particularly among youth [35, 48-56].

However, it is also possible that vaping could denormalise and reduce smoking. In this thesis, I found evidence to suggest that vaping could change norms towards smoking, and also smoking behaviour, among youth, and that both renormalisation and denormalisation effects are possible [1, 3]. I also found that these effects may differ across countries [3]. Further, while I found that vaping was positively associated with initiating smoking, I also found that this association might work both ways [1]. Importantly, in Great Britain, I found that vaping was largely confined to youth who had ever smoked [1], which appears contrary to concerns that vaping is attracting never smoking youth into nicotine use [35, 48-51]. Further research is required to replicate and extend my findings and to establish the mechanisms through which smoking and vaping norms and behaviours are related, before any firm conclusions can be drawn. Meanwhile, policies should continue to minimise exposure to vaping and access to vaping products among youth who have never smoked.

Some governments have emphasised the importance of adopting a restrictive approach to vaping in order to denormalise vaping and reduce use among non-smokers and youth [35, 53, 275]. While I found that more positive norms towards vaping were associated with vaping among youth [1, 3], I also found that there was little overall correspondence between vaping norms and vaping policies and prevalence rates. Of particular note are my findings among youth age 16-19 from Canada, England, and the US [3]. At the time of surveying, the sale, use, and advertisement of nicotine-containing e-cigarettes was illegal in Canada [284]. However, in England, the sale and use of all e-cigarettes were legal to individuals over the age of 18, and there was some promotion of e-cigarettes as an aid to smoking cessation [20, 27, 53, 129]. Despite these differences, I found that friend vaping and perceived peer approval of vaping were both higher in Canada [3]. I also found that 50% of Canadian youth reported having friends who vape, while 28% reported vaping themselves [3]. Consistent with previous research [284], my findings suggested that prohibition of e-cigarettes may not stop some youth from vaping and instead might lead to illegal use of e-cigarettes. My findings also suggested that tighter vaping restrictions may not necessarily denormalise vaping.

Considering harm perceptions of vaping and nicotine, I found that only 63% of youth in Great Britain accurately perceived vaping to be less harmful than smoking, while only 9% accurately perceived that none or a small amount of the harm from smoking comes from nicotine [2]. Inaccurate harm perceptions could discourage smokers from switching to a less harmful form of nicotine consumption, [163, 174], including youth who smoke. It is therefore crucial that both youth and adults receive balanced information on the relative health risks of vaping and nicotine in relation to smoking. Governments and public health advocates globally should emphasise that vaping legal products from authorised outlets is a less harmful form of nicotine consumption than smoking, while also emphasising that vaping is not risk-free.

9.10. Conclusions

My findings provided novel insights into the associations between smoking and vaping norms and smoking and vaping behaviours and policies.

Overall, my findings suggested that the smoking behaviours of close others (family and close friends) are strong and consistent predictors of youth smoking initiation, perhaps so than the smoking behaviours of wider social group (peers and society) and injunctive norms [1, 3]. I also found that more positive norms towards vaping were associated with youth vaping, again with stronger associations for descriptive than injunctive norms [1, 3]. My findings support theories proposing that the behaviour of those within one's close social circle predicts that same behaviour [58, 73, 76].

Counter to concerns that vaping could renormalise and increase smoking among youth, I found that friend vaping was protective against smoking among British youth [1], and that perceived peer approval of vaping was negatively associated with vaping among English youth [3]. However, consistent with renormalisation concerns, I found that friend vaping was positively associated with smoking among US youth [3]. Further, using causal mediation analyses, I found that trying vaping predicted smoking initiation, but also that trying smoking predicted vaping initiation, among British youth [1]. Taken together, my findings suggest that vaping could renormalise and increase, or denormalise and decrease smoking, among youth. However, further longitudinal research is required to replicate and extend my findings.

Inconsistent with theories that place social norms on the pathway between tobacco control policies and reductions in smoking prevalence [58-62], I found that smoking was not always more denormalised in countries with stronger tobacco control policies and lower smoking prevalence among youth, and adult smokers [3-5]. I also found that vaping norms did not always correspond with vaping policies or prevalence rates across countries [3, 4]. However, I was not able to assess smoking norms among general populations of adults across countries or over time.

Taken together, my findings suggested that the relationship between norms, behaviours, and policies is more complex than theorised. This may question whether smoking denormalisation is a valid approach to tobacco control, at least to the extent that denormalisation is conceptualised as a reduction in how common and approved of smoking is perceived to be. Tobacco control policies should continue to prioritise reducing smoking prevalence directly and reducing youth exposure to smoking, particularly within youth's close social circles and at home. Similarly, my findings suggested that more restrictive vaping policies may not necessarily denormalise vaping among adult smokers and youth. However, further longitudinal studies are required to understand the mechanisms through which smoking and vaping norms, behaviours, and policies are related.

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Appendices

Appendix A. PRISMA checklist

Table A1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist

Section/ topic	#	Checklist item	Location reported
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Chapter 2 (pg 19)
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Not provided in this thesis
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Section 2.2 (pg 20)
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Section 2.2 (pg 21)
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Section 2.3.1 (pg 21)
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Section 2.3.3.1 (pg 22)
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Section 2.3.2 (pg 21)
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix B
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Section 2.3.3.2 (pg 23)
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Section 2.3.4 (pg 24)
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Appendix E

Table A1 continued below.

Table A1 (continued). Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist

Section/ topic	#	Checklist item	Location reported
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Section 2.3.5 (pg 25)
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Section 2.3.6 (pg 25)
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Section 2.3.6 (pg 25)
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Section 2.3.5 (pg 25)
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Section 2.3.6 (pg 25)
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Section 2.4 (pg 27) and Figure 2.1 (pg 28)
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Section 2.4.1 (pg 29) and Table A2 (Appendix E, pg 258)
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Section 2.4.1 (pg 29) and Table A2 (Appendix E, pg 258)
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Section 2.4.2 (pg 30) and Section 2.4.3 (pg 30)
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Section 2.4.3 (pg 41)
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Section 2.4.5 (pg 48)
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	Section 2.4.4 (pg 46)
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Section 2.5 (pg 50)

Table A1 continued below.

Table A1 (continued). Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist

Section/ topic	#	Checklist item	Location reported
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Section 2.5.1 (pg 54)
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Section 2.5.3 (pg 55)
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Section 2.1.2 (pg 20)

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

Appendix B. Search terms and search strategy

MEDLINE (via PubMed): (Smok*[MeSH]) OR Tobacco[MeSH] OR Cigarette[MeSH] or Cigarettes[MeSH]) AND (attitude*[tiab] OR belief*[tiab] OR believe*[tiab] OR perception*[tiab] OR perceive*[tiab] OR norm*[tiab] OR renorm*[tiab] OR denorm*[tiab] OR opinion*[tiab] OR motivat* [tiab] OR approv*[tiab] OR disapprov*[tiab] OR accept*[tiab] OR societ*[tiab] OR social*[tiab] OR *stigma*[tiab] OR prejudice*[tiab] OR stereotyp*[tiab]) AND (youth*[tiab] OR school*[tiab] OR adolescen*[tiab] OR young people*[tiab] OR young person*[tiab] OR young adult*[tiab] OR child*[tiab] OR teenage*[tiab]) AND (longitudinal*[tiab] OR prospective[tiab] OR cohort*[tiab] OR follow-up*[tiab] OR follow up*[tiab] OR baseline[tiab] OR wave*[tiab] OR panel*[tiab] OR predict*[tiab])

EMBASE and PsycINFO (via Ovid): (Smok* or tobacco* or cigarette*).sh. and (attitude* or belief* or believe* or perception* or perceive* or norm* or renorm* or denorm* or opinion* or motivat* or approv* or disapprov* or accept* or societ* or social* or *stigma* or prejudice* or stereotyp*).ti,ab. and (youth* or school* or adolescen* or young people or young person* or young adult* or child* or teenage*).ti,ab. and (longitudinal* or prospective or cohort* or follow-up* or follow up* or baseline or wave* or panel* or predict*).ti,ab.

CINAHL (via EbscoHost): (MW smok* OR MW tobacco* OR MW cigarette*) AND (TI attitude* OR AB attitude* OR TI belief* OR AB belief* OR TI believe* OR AB believe* OR TI peception* OR AB peception* OR TI perceive* OR AB perceive* OR TI norm* OR AB norm* OR TI renorm* OR AB renorm* OR TI denorm* OR AB denorm* OR TI opinion* OR AB opinion* OR TI motivat* OR AB motivat* OR TI approv* OR AB approv* OR TI disapprov* OR AB disapprov* OR TI accept* OR AB accept* OR TI societ* OR AB societ* OR TI social* OR AB social* OR TI *stigma* OR AB *stigma* OR TI prejudice* OR AB prejudice* OR TI stereotyp* OR AB stereotyp*) AND (TI youth* OR AB youth* OR TI school* or AB school* OR TI adolescen* OR AB adolescen* OR TI young people OR AB young people OR TI young person OR AB young person OR TI young adult* OR AB young adult* OR TI child* OR AB child* OR TI teenage* AB teenage*) AND (TI longitudinal* OR AB longitudinal* OR TI prospective OR AB prospective OR TI cohort* OR AB cohort* OR TI follow-up* OR AB follow-up* OR TI follow up* OR AB follow up* OR TI baseline OR AB baseline OR TI wave* OR AB wave* OR TI panel OR AB panel* OR TI predict* OR AB predict*)

All searches were limited: from 01/01/1998 – 01/07/2019, to human, and to English language.

Reference lists of included articles and relevant reviews were also screened to identify further articles.

Appendix C. Narrative synthesis data extraction sheet headings

Article description: Authors, title, year of publication, journal, objectives, type (e.g. peer-reviewed journal article, dissertation), dataset, theoretical basis, conflicts of interest.

Design: Location (country, area), setting, population, sampling strategy, study inclusion/exclusion criteria, method of data collection, year of data collection at baseline, number of waves, length of longest follow-up.

Respondents: Number of respondents in analyses, age at baseline (range, mean and standard deviation), % female at baseline, ethnicity at baseline, socio-economic status at baseline, smoking status at baseline.

Exposure(s): All self-reported measures of norms assessed and details on wording and coding.

Outcome(s): Smoking initiation/escalation outcome(s) assessed and details on wording and coding.

Analyses and result(s): Description of associations between norms and smoking initiation/escalation provided in the article (at longest follow-up), analyses used, variables adjusted for.

Potential sources of bias: Response rate, attrition rate, details of attrition analyses, method of dealing with missing, Newcastle-Ottawa Scale score, other potential sources of bias or attempts to address bias.

Appendix D. Meta-analysis data extraction sheet headings

Article description: Authors, title, year of publication, journal, type (e.g. peer-reviewed journal article, dissertation), conflicts of interest.

Design: Location (country, area), setting, population, sampling strategy, method of data collection, year of data collection at baseline, length of follow-up.

Respondents: Number of respondents in analyses, age at baseline (range, mean and standard deviation), % female at baseline, % white at baseline.

Outcome(s): Measurement and coding of smoking initiation.

Analyses and result(s): Parent smoking: OR, Parent smoking: low CI, Parent smoking: high CI, Parent smoking: SE, Sibling smoking: OR, Sibling smoking: low CI, Sibling smoking: high CI, Sibling smoking: SE, Friend smoking: OR, Friend smoking: low CI, Friend smoking: high CI, Friend smoking: SE, Best friend smoking: OR, Best friend smoking: low CI, Best friend smoking: high CI, Best friend smoking: SE, Peer prevalence: OR, Peer prevalence: low CI, Peer prevalence: high CI, Peer prevalence: SE, Household/Family smoking: OR, Household/Family smoking: low CI, Household/Family smoking: high CI, Household/Family smoking: SE, Adult smoking prevalence: OR, Adult smoking prevalence: low CI, Adult smoking prevalence: high CI, Adult smoking prevalence: SE, Parent approval: OR, Parent approval: low CI, Parent approval: high CI, Parent approval: SE, Sibling approval: OR, Sibling approval: low CI, Sibling approval: high CI, Sibling approval: SE, Friend/peer approval: OR, Friend/peer approval: low CI, Friend/peer approval: high CI, Friend/peer approval: SE, Public approval: OR, Public approval: low CI, Public approval: high CI, Public approval: SE, Important people approval: OR, Important people approval: low CI, Important people approval: high CI, Important people approval: SE, Pressure parents: OR, Pressure parents: low CI, Pressure parents: high CI, Pressure parents: SE, Pressure siblings: OR, Pressure siblings: low CI, Pressure siblings: high CI, Pressure siblings: SE, Pressure friends: OR, Pressure friends: low CI, Pressure friends: high CI, Pressure friends: SE, variables adjusted for in analyses.

Potential sources of bias: Newcastle-Ottawa Scale score.

Appendix E. Description of articles included in the systematic review and meta-analysis

Table A2. Description of articles included in the systematic review and meta-analysis. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
INCLUDED IN SYSTEMATIC REVIEW AND META-ANALYSIS						
Barring-ton-Trimis 2016 [146]	WS/DS Schools US 16	N=298 Mean age 17.4 † 42% female 49% Hispanic 42.3% white	*Friend smoking:* At least one of four closest friends smoke *Household smoking:* Anyone who lives with you smokes *Friend approval:* Best friends are 'friendly' towards you if you smoked	Initiation: Any smoking	LogR (AP, E, G, SES)	3
Bernat 2008 [201]	TS Households US 36	N=3637 Age 12-16 † 51% female 84% white	*Parent smoking:* Have a parent who smokes *Friend smoking:* Number of four closest friends who smoke (0-4; continuous) *Peer smoking prevalence:* Prevalence of smoking among teenagers the same age as respondent (0-4; none-almost all; continuous) *Adult smoking prevalence:* Prevalence of smoking among adults (0-4; none-almost all; continuous)	Escalation: Trajectories	LogR (A, E, FS, HSR, L, N, TIP, TPB)	4
Bernat 2012 [103]	TS Households US 36	N=2034 Age 18-21 † 51% female 89% white	*Friend smoking:* Number of four closest friends who smoke (0-4; continuous) *Peer smoking prevalence:* Prevalence of smoking among teenagers the same age as respondent (0-4; none-almost all; continuous) *Household smoking:* Anyone in household smokes *Adult smoking prevalence:* Prevalence of smoking among adults (0-4; none-almost all; continuous) *Parent approval:* Smoking would bother parents a lot	Initiation: Any smoking	T-test, X^2, LogR (A, E, G, L, N, SX, TPB)	3
Bidstr-up 2009 [198]	WS Schools Denmark 18	N=442 Mean age 13 † 53% female Ethnicity not stated	*Parent smoking: Mother:* Mother smokes. *Father:* Father smokes *Friend smoking:* Best friend smokes *Grouped approval:* Teachers, friends, best friend think…(for each: it's OK to smoke, think I shouldn't smoke, don't care/don't know; combined to form continuous scale from 1-4) *Pressure friend/peer:* Pressure to smoke by friends/best friends/other adolescents (for each: yes, no; combined to form continuous scale from 1-4)	Initiation: Any smoking	LogR (FS, LS, N, R, TPB)	3

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Chang 2006 [104]	WS Schools Taiwan 24	N=1654 Age 15-16 † 42% female Ethnicity not stated	*Parent smoking:* Have a parent who smokes *Friend smoking: Best friend:* Best friend smokes. *Friends:* Over half of friends smoke. *Parent approval:* Parents disapprove of smoking *Friend approval:* Friends disapprove of smoking *Societal approval:* Community disapproves of smoking	Initiation: Any smoking in the past year among past-year never smokers	LogR (N, PB, peer offers cigarette s, TPB)	4
Chassin 2005 [205]	FS/TS Households US 24	N=382 Age 10-17 (mean=13) 51% female 98% white	*Parent smoking:* Have a parent who smokes *Parent approval:* Eight items, e.g. parents would discuss talk to respondent about reasons not to smoke if they found out respondent smoked; parents would withdraw privileges if they found out respondent smoked (both: 1-5; no way-yes definitely; continuous)	Escalation: Increase in smoking from being a never smoker or less-than-monthly smoker at baseline (yes, no)	LogR (A, BS, FS, N, SES)	5
Conner 2017 [152]	WS Schools GB 12	N=2044 Age 13-14 (mean=13) 51% female Ethnicity not stated	*Family smoking:* Number of family members who smoke (0, 1, 2, 3+) *Friend smoking:* Proportion of friends who smoke (none, a few, most) *Grouped approval:* Most friends, best male friend, best female friend, family, people important to me think I…(for each: 1-5, should smoke to should not smoke; mean taken to form continuous scale)	1. Initiation: Any smoking 2. Escalation: Initiation of rarely, occasional, or frequent smoking from having tried or used to smoke	LogR (EC, G, ITS, N, SES, TBP)	5
Dalton 2003 [196]	WS/TS Schools US 26	N=2603 Age 10-14 (mean=12) 53% female 94% white	*Parent smoking:* Have a parent who smokes *Sibling smoking:* Have a sibling who smokes *Friend smoking:* Have friends who smoke *Parent approval:* Neither/one parent would disapprove of smoking (vs. both would disapprove)	Initiation of any smoking	LogR (A, G, school)	3
Doubeni 2008 [211]	FS Schools US 48	N=1195 Age 11-14 (mean=12) 52% female 73% white	*Parent smoking:* Have a parent who smokes *Household smoking:* Presence of adult smokers in home *Friend smoking:* How many of respondents four closest friends smoke (0-4) *Parent approval:* Parents would be upset if you smoked *Friend approval:* Friends would be happy if you smoked	1. Initiation: Any smoking 2. Escalation: Initiation of ≥weekly smoking from baseline never/less-than-weekly smoking	Survival analyses (A, CA, concerns about weight, G, LS, N, PB, PS)	2

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
East 2018 [1]	DS Online survey GB 6	N=923 Age 11-18 † 54% female Ethnicity not stated	*Parent smoking:* Have a parent who smokes *Sibling smoking:* Have a sibling who smokes *Friend smoking:* Have some friends who smoke *Societal approval:* The public approve of smoking	Initiation: Any smoking	LogR (A, AP, EC, ECN, G, ITS, N, PB)	4
Grogan 2009 [219]	WS Schools GB 48	N=590 Age 11 † 53% female Ethnicity not stated	*Grouped approval:* My friend, best friend, family thinks respondent… (for each: 1-5, should smoke to should not smoke; combined to form continuous scale)	Initiation: Any past-term smoking	LogR (TPB)	5
Hoving 2007 [194]	WS Schools Finland, Denmark, the United Kingdom, the Netherlands, Spain, and Portugal 12	N=4055 Mean age 13 † 49% female 92% autochthonous	*Parent smoking:* Have a parent who smokes *Friend smoking:* At least half of friends smoke *Parent approval:* Mother and father think respondent…(for each: 0-6; definitely should not-definitely should smoke)* *Friend approval:* Friends think respondent…(0-6; definitely should not-definitely should smoke; continuous) *Pressure parent:* Pressure to smoke from mother/father (for each: 0-4; never-very often)* *Pressure friend:* Pressure to smoke from friends (for each: 0-4; never-very often)* *Mean taken for each set of norms to form a continuous scale.	Initiation: At-least-monthly smoking	LogR (A, ITS, L, N, PB, R, SES, TPB)	3
Hukkelberg 2009 [220]	WS Schools Norway 12	N=760 Mean age 14 † 50% female Ethnicity not stated	*Grouped approval:* People important to me think I should not smoke (1-7; disagree-agree; continuous)	Escalation: Smoking stage (every day, 3–5 times a week, 1–2 times a week, seldom, quit, never smoked)	SEM (BS, TPB)	2

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Otten 2008 [195]	WS Schools The Netherlands 24	N=4351 Age 11-16 (mean=13) 53% female 56% White	*Parent smoking:* Parents smoke (both, one, neither) *Parent approval:* Parents allow smoking in the house; parents would not find out if respondent smoked; respondent expects negative consequences parents found out about them smoking; parents often talk with respondent about not smoking; respondent disregards explicit requests of parents not to smoke (all: 1-5; definitely not true-definitely true; summed to form continuous scale)	Initiation: Any smoking	SEM (A, AP, G, N, PS)	3
Shete 2017 [102]	FS/DS Households US 60	N=973 Age 11-14 (mean=12) 52% female 100% Mexican-American	*Friend smoking:* Have at least a few friends who smoke *Household smoking:* Father/mother/brother/sister/anyone else living at home smokes *Adult smoking prevalence:* At least a few of your parents' friends smoke	Initiation: Any smoking	LogR (A, FS, G, ITS, L, MH, N, SES, SX, language)	2
Valente 2013 [209]	WS Schools US 12	N=1950 Age 14 † 59% female 80% Hispanic/ Latino	*Friend smoking:* Number (0-5; continuous) and proportion of five closest friends who smoke (%; continuous) *Peer smoking prevalence:* Percentage of students the same as respondents who smoke (0-100 in intervals of 10, e.g. 0, 10, 20…; continuous)	1. Initiation: Any smoking 2. Escalation: Any smoking while controlling for baseline never vs. any smoking	LogR (A, AP, BS, E, friendships, G, L, N, SES)	2
Wang 2011 [213]	WS Schools Hong Kong 24	N=2171 Mean age 8† 48% female Ethnicity not stated	*Parent smoking:* Parent smoking (coding not stated) *Peer smoking prevalence:* What proportion of primary school children in Hong Kong have smoked (none/some, half, majority, all)	Initiation: Any smoking	LogR (A, G, L, school, SHS, N)	3
INCLUDED IN SYSTEMATIC REVIEW ONLY						
Allem 2015 [91]	WS/DS/TS Schools US 60	N=932 Mean age 16 † 56% female 100% Hispanic	*Parent smoking:* Have an adult close to you who smokes *Sibling smoking:* Have a sibling who smokes *Peer smoking prevalence:* Prevalence of smoking in school year among those the same gender as respondent (0-100; continuous) *Friend approval:* Close friend approval of smoking	Escalation: Change in past-month smoking	LogR (BS, R, discrim-ination, fatalism, N)	2
	Reason excluded from meta-analysis: Sample repeated from [209]. Source [209] was prioritised because it assessed the outcome smoking initiation.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Carvajal 2006 [214]	WS Schools US 10	N=1137 Age 11-14 † 55% female 43% Latino, 29% white	*Parent approval:* How parents would feel if you smoked and how important it is for you to do what parents want (coding not specified; continuous) *Friend approval:* How best friends and classmates would feel if you smoked and how important it is for you to do what friends want (coding not specified; continuous)	Initiation: Any smoking	LogR (A, AP, E, G, ITS, LS, MH, N, PS, SES, SX, TPB)	4
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					
Choi 2011 [192] (Manuscript 3 only)	TS Households US 78	N=3112 Age 12-14 (mean=13) % female not stated 84% white	*Adult smoking prevalence:* Prevalence of smoking among adults (1-5; none-almost all; continuous)	Escalation: Escalation in smoking stage	Crossla-gged mediat-ion (A, BS, E, G, L, SES)	3
	Reason excluded from meta-analysis: Sample repeated from [103, 201]. Sources [103, 201] were prioitised because [103] assessed the outcome smoking initiation and [201] assessed a greater number of smoking norms. Sources [201] and [103] could both be included because they used different sample waves.					
Colder 2008 [208]	DS/MS University US 8	N=193 Age 18-20 † 48% female 95% white	*Family smoking:* Smoking among family in household (0, 1, 2+) *Friend smoking:* Number of five closest school friends who smoke (0-5), How often around school friends while they smoked (not at all, a little, a lot) *Friend smoking:* Smoking of three people you spend the most time with, other than partner (for each: 0-6; does not smoke-smokes a lot; mean taken to form continuous scale) *Peer smoking prevalence:* Prevalence of smoking among students (0-10; continuous) *Friend approval:* Approval of smoking among the three people you spend the most time with, other than partner (for each: 0-6; disapprove strongly-approve strongly; mean taken to form continuous scale)	Escalation: Trajectories (large increasers, small increasers, sporadic smokers, steady decreasers [moderate smoker, low smoker], early decreasers [moderate smoker, low smoker])	ANOVA and X^2	2
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Conner 2006 [82] (Study 2 only)	WS Schools GB 24	N=674 Age 11-12 † 49% female Ethnicity not stated	*Grouped approval:* Friends, best friend, people important to me think I…(for each: 1-5; should not smoke-should smoke), People important to me want me to smoke (1-5; unlikely-likely), People my age are trying to get me to smoke (1-5; strongly disagree-strongly agree) (mean of all taken to form continuous scale)	Initiation: Any smoking (measured using carbon monoxide levels)	LinR (ITS, SX, TPB)	3
	Reason excluded from meta-analysis: Sample repeated from [93, 219]. Source [219] was prioritised because it assessed the outcome smoking initiation.					
Dalton 2009 [197]	WS/TS Schools US 96	N=1791 Age 10-14y (mean=12y) 54% female 91% white	*Parent smoking:* Have a parent who smokes *Sibling smoking:* Have a sibling who smokes *Friend smoking:* Have friends who smoke *Parent approval:* Neither/one parent would disapprove of smoking (vs. both would disapprove)	Initiation: Established smoking (>100 cigarettes in life)	LogR (A, AP, G, MSE, N, PB, PS, RTA, school, SE, SES)	3
	Reason excluded from meta-analysis: Sample repeated from [101, 196, 206, 207]. Source [101] was initially prioritised because it assessed the outcome of smoking initiation, however summary statistics for the association between norms and smoking initiation were unavailable. Source [196] was prioritised because it assessed the most smoking norms.					
Etcheverry 2008 [92]	DS University US 9	N=912 Age 17-19 † 46% female 92% white	*Parent smoking: Mother:* Mother smokes. *Father:* Father smokes *Friend smoking:* Number of five closest friends in high school who smoked (0-5; continuous) and smoking of three people you spend the most time with, other than partner (for each: 0-6; does not smoke-smokes a lot; mean taken to form continuous scale) *Partner smoking:* Partner smokes (0-6; does not smoke-smokes a lot) *Friend approval:* Of the three people you spend the most time with other than partner, would they approve or disapprove of you smoking? (0-6; strong disapproval-strong approval; mean taken to form continuous scale) *Partner approval:* Partner would approve or disapprove of your smoking (0-6; strong disapproval-strong approval)	Escalation: Cigarettes per day among those who had ever tried smoking	GCM (BS, G, N, relationship status)	2
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Glass 2013 [193]	DS University US 9	N=449 Age 17-23 (mean=18) 78% female 86% white	*Friend smoking:* Percentage of close friends who smoke (0-100; continuous) *Peer smoking prevalence:* Percentage of students at university who smoke (0-100; continuous)	Escalation: Cigarettes per week (continuous)	GCM (A, BS, E, G, MH, N)	3
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					
Grenard 2006 [212]	WS Schools China 12	N=11583 Age 12-17 (mean=15) 51% female 95.4% Han Asian	*Friend smoking:* How many good friends smoke at least once a month? (0-3; none-all; continuous) *Peer smoking prevalence:* Percentage of students your age who smoke (0-100 in intervals of 10, e.g. 0, 10, 20…; continuous)	Escalation: Past-month smoking (yes, no)	MGLM (A, AP, BS, G, ITS, L, MH, N, PB, PS, SES, TPB)	3
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					
Harakeh 2004 [133]	WS Schools The Netherlands 6	N=1070 Age 10-14 (mean=12) 49% female Ethnicity not stated	*Parent smoking:* Have a parent who smokes *Friend approval:* Friends approve of smoking (1-5; definitely not-definitely yes; continuous)	Initiation of any smoking	SEM (ITS, PS, N, TPB)	3
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Kremers 2004 [204]	WS Schools Finland, Denmark, GB, The Nether-lands, Spain, and Portugal 12	N=6729 Mean age 13 † 50% female Ethnicity not stated	*Parent smoking:* Mother/father smokes* *Sibling smoking:* Brother/sister smokes* *Friend smoking/peer smoking prevalence:* Do your friends/people in same school year smoke? *Parent approval:* Father/mother thinks you…(for each: 0-6; certainly shouldn't smoke-certainly should smoke)* *Sibling approval:* Brother/sister thinks you…(for each: 0-6; certainly shouldn't smoke-certainly should smoke)* *Friend/peer approval:* Friends/best friend/people in same school year thinks you…(for each: 0-6; certainly shouldn't smoke-certainly should smoke)* *Pressure parent:* Pressure to smoke from mother/father (for each: 0-4; never-very often)* *Pressure sibling:* Pressure to smoke from brother/sister (for each: 0-4; never-very often)* *Pressure friend:* Pressure to smoke from friends/best friend/people in the same school year (for each: 0-4; never-very often)* *Each set of norms summed to form a continuous scale.	Escalation: Smoking stage (yes vs. stable/regressed) from less-than-weekly smokers at baseline	ANOVA (A, G, L)	3
	Reason excluded from meta-analysis: Sample repeated from [194, 199]. Source [194] was prioritised because it assessed the outcome smoking initiation.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Lotrean 2013 [202]	WS Schools Romania 9	N=504 Age 13-14 (mean=14) 53% female Ethnicity not stated	*Parent smoking: Mother:* Mother smokes. *Father:* Father smokes *Sibling smoking: Sister:* Sister smokes. *Brother:* Brother smokes *Friend smoking:* Friends smoke (0-4; nobody-everybody; continuous); 2. Best friend smokes *Peer smoking prevalence:* People in the same school year smoke (0-4; nobody-everybody; continuous) *Parent approval:* Mother/father thinks respondent should…(for each: 0-6; definitely should not smoke-definitely should smoke)* *Sibling approval:* Brother/sister thinks respondent…(for each: 0-6; definitely should not smoke-definitely should smoke)* *Friend/peer approval:* Friends/best friend/people in the same school year) think respondent… (for each: 0-6; definitely should not smoke-definitely should smoke)* *Pressure parent:* Pressure to smoke from mother/father (for each: 0-4; never-very often)* *Pressure sibling:* Pressure to smoke from brother/sister (for each: 0-4; never-very often)* *Pressure friend/peer:* Pressure to smoke from friends/best friend/people in the same school year (for each: 0-4; never-very often)* *Each set of norms combined to form a continuous scale	Escalation: Initiation of at-least-weekly smoking from less-than-weekly smokers at baseline	Correla-tion and LogR (AP, FS, G, ITS, N, PB, SES, TPB)	3
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
McMill-an 2005 [93]	WS Schools GB 3	N=620 Age 12-13 † 48% female Ethnicity not stated	*Friend smoking:* How many friends smoke? (0-4; none-all; continuous) *Family smoking:* Mum/dad/grandmother/grandfather/older brother/younger brother/older sister/younger sister/others smoke (0-9; continuous) *Grouped approval:* Friends/best friend/people who are important to respondent think they…(for each: 1-5; should not smoke–should smoke). People important to respondent want them to smoke…(1-5; unlikely-likely). People same age as respondent are trying to get them to smoke…(1-5; strongly disagree-strongly agree) (scores combined to form continuous scale)	Escalation: Ever smoked in past school term	LogR (BS, ITS, N, SX, TPB)	3
	Reason excluded from meta-analysis: Sample repeated from [82, 219]. Source [219] was prioritised because it assessed the outcome smoking initiation.					
Mercken 2011 [199]	WS Schools The Netherlands 24	N=1475 Mean age 13 † 50% female 76% white	*Parent smoking:* Have a parent who smokes *Sibling smoking:* Have a sibling who smokes *Parent approval:* Mother/father thinks respondent…(for each: 0-6; definitely should not smoke-definitely should smoke)* *Sibling approval:* Brother(s)/sister(s) thinks respondent…(for each: 0-6; definitely should not smoke-definitely should smoke)* *Friend/peer approval:* Friends/best friend think respondent…(0-6; definitely should not smoke-definitely should smoke)* *Pressure friend:* Pressure to smoke from friends/best friend (0-4; never-very often)* *Mean taken for each set of norms combined to form a continuous scale	Escalation: Cigarettes per week (0, 1, 1-10, 11-30, ≥30)	SEM (A, BS, E, G, ITS, N, PB, TPB)	3
	Reason excluded from meta-analysis: Sample repeated from [194, 204]. Source [194] was prioritised because it assessed the outcome smoking initiation.					
O'Brien 2018 [210]	WS/DS Schools US 48	N=2659 Mean age 16 † 55% female 56% white	*Friend smoking:* Frequency their five closest friends smoke (never, almost never/sometimes, often/almost always) *Parent approval:* How important it is to parents/guardians that respondent does not use cigarettes (1-7; not at all-extremely)	Escalation: Past month smoking frequency (never, 1-5 times, 6+ times)	Ordinal LogR (BS, E, FS, G, MH, N, PB, PS, school, SES)	3
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures		Analysis (covari-ates)	NOS
			Social norms (coding) [a]	Smoking outcome (coding)[a]		
Otten 2007 [216]	WS Households The Netherlands 12	N=314 Age 13-17 (mean=13 younger siblings, 15 older siblings) Gender, ethnicity not stated	*Parent approval:* Mother/father approves of smoking (for each: 1-4; definitely not-definitely) *Friend approval:* Friends approve of smoking (1-4; definitely not-definitely)	Escalation: Smoking stage (never, tried smoking but don't smoke any more, smoked at least monthly but not any more, occasional, daily) from baseline never smoking	SEM (N, parent self-report smoking and communication about smoking, TPB)	3
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					
Otten 2009 [200]	WS Schools The Netherlands 22	N=6769 Age 11-16 (mean=13) 52% female Ethnicity not stated	*Parent smoking:* At least one parent smokes *Friend smoking: Best friend:* Best friend is a smoker. Friend: Over half of friends smoke *Peer smoking prevalence:* Overestimation of lifetime smoking among adolescents the same age as respondents	Escalation: Smoke at least once a month	LogR (A, BS, educat-ion, G, N)	4
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					
Sargent 2004 [207]	WS/TS Schools US 26	N=2596 Age 10-14 (mean=12) 53% female 95% white	*Friend smoking:* Have friends who smoke *Family smoking:* Have a parent or sibling who smokes *Parent approval:* Neither/only one parent disapproves of smoking (vs. both disapprove)	Initiation: Any smoking	LogR (A, AP, G, movie restrict-ion, MSE, N, PS, RTA, SE, SES)	3
	Reason excluded from meta-analysis: Sample repeated from [101, 196, 197, 206]. Source [101] was initially prioritised because it assessed the outcome of smoking initiation, however summary statistics for the association between norms and smoking initiation were unavailable. Source [196] was therefore prioritised because it assessed the most smoking norms.					
Sargent 2008 [206]	WS/TS Schools US 26	N=2603 Age 10-14 † 53% female >90% white	*Friend smoking:* Have friends who smoke *Family smoking:* Have a parent or sibling who smokes *Parent approval:* Neither/only one parent disapproves of smoking (vs. both disapprove)	Initiation: Any smoking	LogR (A, AP, G, MSE, N, PB, school, PS, RTA, SE, SES)	3
	Reason excluded from meta-analysis: Sample repeated from [101, 196, 197, 207]. Source [101] was initially prioritised because it assessed the outcome of smoking initiation, however summary statistics for the association between norms and smoking initiation were unavailable. Source [196] was therefore prioritised because it assessed the most smoking norms.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Tickle 2006 [101]	WS/TS Schools US 26	N=2541 Not stated	*Parent smoking:* Parent smoking (neither, one, both) *Sibling smoking:* Have a sibling who smokes *Friend smoking:* How many friends smoke? (0-3; none-all; continuous) *Peer smoking prevalence:* Most kids like you start smoking (0-3; definitely yes-definitely no; continuous) *Adult smoking prevalence:* Most adults smoke (0-3; definitely yes-definitely no; continuous)	Initiation: Any smoking	SEM (not stated)	3
	Reason excluded from meta-analysis: Sample repeated from [196, 197, 206, 207]. This source was initially prioritised because it assessed the outcome of smoking initiation, however summary statistics were unavailable. Source [196] was prioritised because it assessed the most smoking norms.					
Van de Ven 2007 [215]	WS Schools The Netherlands 18	N=4079 Age 12-16 (mean=13) 53% female 83% Dutch	*Parent approval:* Parents would approve of respondent smoking (1-4; definitely not-definitely yes; continuous) *Friend approval:* Best friend/friends would approve of respondent smoking (1-4; definitely not-definitely yes; mean taken to form continuous scale)	Initiation: Any smoking	SEM (TPB)	4
	Reason excluded from meta-analysis: Sample repeated from [195]. This source was initially prioritised because it assessed the most injunctive norms; initiation, however summary statistics were unavailable. Source [195] was prioritised because sufficient data were available in the source.					
Van den Eijnden 2006 [217]	WS Schools The Netherlands 12	N=612 Age 11-13 (mean=12) 53% female 95% Dutch	*Friend approval:* Best friend/friends would approve of respondent smoking (1-4; definitely not-definitely yes; combined to form continuous scale)	Escalation: Smoking stage	LinR (BS, TPB)	3
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					
Van Zundert 2006 [218]	WS Schools The Netherlands 12	N=397 Age 11-15 (mean=12) 46% female 95% Dutch	*Friend approval:* Best friend/friends would approve of respondent smoking (1-5; certainly not-certainly yes; mean taken to form a continuous scale)	Escalation: Smoking stage among those who had ever tried smoking	LogR (A, AP, E, G, TPB)	4
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					

Table A2 continued below.

Table A2 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Design, country, months' follow-up	Sample	Measures: Social norms (coding) [a]	Measures: Smoking outcome (coding)[a]	Analysis (covari-ates)	NOS
Xie 2013 [203]	WS Schools China 60	N=3521 Age 12-15 † 47% female Ethnicity not stated	*Parent smoking:* Have a parent who smokes *Peer smoking prevalence:* Proportion of people the same age as respondent who smoke (0-100; continuous) *Parent approval:* 1. How parents would act if you smoked (1-5; very badly-very well; dichotomised but coding not specified), 2. Mother/father would agree if respondent wanted to smoke (1-4; definitely not-definitely yes) *Friend approval:* How friends would act if you smoked (1-5; very badly-very well; dichotomised but coding not specified) *Teacher approval:* How teachers would act if you smoked (1-5; very badly-very well; dichotomised but coding not specified)	Escalation: Trajectories (nonsmoker, stable light/ occasional smoker, accelerating smoker)	GCM (AP, FS, G, L, MH, N, PB, PS, school, SES, TPB)	4
	Reason excluded from meta-analysis: Summary statistics for the association between norms and smoking initiation unavailable.					

NOS=Newcastle-Ottawa Scale, score out of 5 stars with a score of ≤3 stars indicating high risk of bias. *Design*: WS=Written Survey, TS=Telephone Survey, DS=Digital Survey, MS=Mail Survey, FS=Face-to-face Interview Survey. *Country:* GB=Great Britain, US=United States. *Demographics:* M=Months, SD=Standard Deviation, Y=Years. *Analysis:* ANOVA=Analysis of Variance, GCM=Growth Curve Models, LogR=Logistic Regression (or similar form, e.g. general linear model with log link), LinR=Linear Regression, MGLM=Multilevel Generalised Linear Model, SEM=Structural Equation Modelling, X^2=Chi Squared. *Covariates*: A=Age, AP=Academic Performance, BS=Baseline Smoking, CA=Cigarette Accessibility, E=Ethnicity, EC=Vaping, ECN=Vaping norms, ED=Education, FS=Family Structure/relationships, G=Gender, HSR=Home Smoking Restrictions, ITS=Intention/susceptibility To Smoke, L=Location, LS=Liking School/positive school experiences, MH=Mental Health, MSE=Movie Smoking Exposure, N=Norms, PB=Problem Behaviour (includes alcohol/drug use, sensation-seeking, rebelliousness), PS=Parenting Style, R=Religion/culture, RTA=Receptivity to Tobacco Advertising, SE=Self-Esteem, SX=Smoking eXpectancies, SES=Socio-Economic Status, SHS=exposure to Second-Hand Smoke, TIP=Tobacco Industry Perceptions, TPB=Theory of Planned Behaviour measures (attitude, self-efficacy, perceived behavioural control, anticipated regret).

Appendix F. Narrative synthesis of associations between smoking norms and smoking initiation and escalation

Table A3. Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
		PARENT SMOKING			
		Initiation of smoking			
[1]	✓	Having at least one parent who increased the odds of initiating any smoking in unadjusted (OR=2.99 [1.72-5.20]) and adjusted (2.97 [1.62-5.44]) analyses.	LogR (A, AP, N, EC, ECN, G, ITS, PB, N (DN friend, DN sibling, IN public))	6	923
[133]	✓	Having at least one parent who smokes increased the risk of initiating any smoking (coef=.41, p<.05)	SEM (ITS, PS, TPB, N (IN friend))	6	1070
[194]	✓	Parent smoking increased the odds of at-least-monthly smoking initiation among girls (OR=1.54 [1.10-2.16]) and boys (2.60 [1.76-3.83]).	LogR (A, ITS, L, PB, R, SES, TPB, N (DN friend, IN parent, IN friend, pressure parents, pressure friends))	12	4055
[195]	✓	Parent smoking was positively directly associated with initiating any smoking (β=0.07, p<.001).	SEM (A, ED, G)	24	4351
[101]	✓	All norms were directly related to initiation of any smoking (no statistics reported).	Not stated	24	2541
[196]	✓	Those with at least one parent who smokes had greater risk of initiating any smoking (RR=2.25 [1.77–2.86])	LogR (A, G, school)	26	2603
[197]	✓	Having at least one parent who smokes increased the odds of initiation of established smoking (smoking >100 cigarettes in life) in the minimally (RR=1.91 [1.58–2.31]) and fully (1.36 [1.05–1.76]) adjusted models.	GLM (minimally: A, G, school; fully: minimally + AP, SES, MSE, PB, PS, RTA, SE, N (DN sibling, DN friend, IN parent))	96	1791
[198]	✓/×	Mothers' smoking increased the odds of initiating any smoking in unadjusted (OR=1.8 [1.2-2.9]) and adjusted (1.5 [0.9-2.5]) analyses. Fathers' smoking increased the odds of initiating any smoking in unadjusted (1.8 [1.1-2.8]) but not adjusted (1.6 [0.9-2.7]) analyses.	LogR (FS, LS, R, TPB, N (DN friend, IN grouped, friend pressure))	18	442
[104]	×	Little evidence of an association between parent smoking and initiation of past-year smoking among baseline past-year never smokers in unadjusted analyses (OR=1.14 [0.84-1.53]). Parent smoking was not assessed in adjusted models.	LogR	24	1654
[211]	?	Not reported	Not reported		
[213]	?	Not reported	Not reported		
		Escalation of smoking			
[199]	✓	Having at least one parent who smokes was associated with an increase in cigarettes smoked per week (B=0.49, SE=0.16 p<.001).	SEM (A, BS, E, G, ITS, PB, TPB, N (DN sibling, pressure friends))	24	1475

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[200]	✓	Having at least one parent who smokes increased the odds of being an at-least-monthly smoker (OR=1.62 [1.38-1.91]).	LogR (A, BS, ED, G, N (DN friend)	14	6769
[201]	✓	Compared with the non-smoking trajectory, having a parent who smoked increased the odds of being in all five other trajectories (trier: OR=2.40 [1.93-2.98]; occasional user: 3.06 [2.34-4.01]; early onset: 4.37 [3.20-5.97]; late onset: 2.22 [1.64-3.01]; decliner: 8.39 [5.09-13.81]). There was a significant association between parent smoking and trajectory group (X^2=199.14, p<.05).	LogR (A, E, FS, L, HSR, TIP, TPB, N (DN friend, DN peer, DN adult))	36	3637
[203]	✓/×	Having parents who smoke increased the odds of being a stable light/occasional (vs. non-smoker: OR=1.52 [1.28–1.81]) but not an accelerating (vs. non-smoker: 1.59 [0.88–2.86]; vs. stable light/occasional smoker: 1.04 [0.58–1.88]) smoker.	GCM (AP, FS, G, L, MH, PB, PS, school, SES, TPB, N (DN peer, IN parent, IN friend, IN teachers))	96	3521
[204]	✓/×	Parent smoking was positively associated with escalation of smoking from two of seven stages only (committed never smoker: w2=0.01; immotive experimental: w2=0.02; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
[205]	✓/×	There was little evidence of an association between having a parent who smokes and smoking escalation from being a never smoker or less-than-monthly smoker at baseline in either analysis 1 (OR=1.02, p>.05) or 2 (OR=1.11, p>.05). However, there were parent smoking*discussion ($\chi2(1,380)$=8.62, p<.003) and parent smoking*punishment ($\chi2(1,380)$=6.09, p<.02) interactions: when both parents did not smoke, discussing smoking decreased the odds of smoking escalation (OR=0.41, p=.004), but when at least one parent smoked there was little evidence of an association between discussion and smoking escalation (OR=.98, p=.940). For smoking punishment, there were no effects in either subgroup (nonsmoking parents: OR=0.79, p=.384; smoking parent: OR=1.39, p=.212).	LogR (analysis 1: A, BS, FS, SES, N (IN parent discussion); analysis 2: A, BS, FS, SES, N (IN parent punishment))	24	382
[91]	×	The associations between all social norms and change in past-month smoking dissipated by emerging adulthood (p<.05, no statistics reported).	LogR (BS, discrimination, fatalism, R, N (DN sibling, DN peer, IN friend))	60	932
[92]	×	Father (M=-.01, SD=.01, p>.05) and mother (M=.01, SD=.01, p>.05) smoking were not associated change in cigarettes smoked per day among those who had ever tried smoking.	GCM (BS, G, relationship status, N (DN friend, DN partner, IN partner, IN friend))	9	779

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[202]	×	There was little evidence of an association between mother or father smoking and initiation of at-least-weekly smoking from less-than-weekly smokers at baseline in unadjusted (both p>.05; statistics not reported) or adjusted (statistics not reported) analyses.	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN sibling, DN friend, DN peer, IN parent, IN sibling, IN friend, pressure parents, pressure siblings, pressure friends))	9	504
[211]	?	Not reported	Not reported		
SIBLING SMOKING					
Initiation of smoking					
[196]	✓	Having a sibling who smokes increased the risk of initiating any smoking (RR=1.91 [1.42–2.59]).	GLM (A, G, school)	26	2603
[101]	✓	All norms were directly related to smoking initiation (no statistics reported).	Not stated	24	2541
[197]	✓/×	Having any siblings who smoke was associated with initiation of established smoking (>100 cigarettes in life) in the minimally (RR=2.12 [1.50–2.98]) but not fully (1.27 [0.90–1.78]) adjusted models.	GLM (minimally: A, G, school; fully: minimally + AP, MSE, PB, PS, RTA, SE, SES, N (DN parent, DN friend, IN parent))	96	1791
[1]	✓/×	Sibling smoking was associated with increased odds of initiating any smoking in unadjusted (OR=2.83 [1.23-6.51]) but not adjusted (0.75 [0.30-1.84]) analyses.	LogR (A, AP, EC, ECN, G, ITS, PB, N (DN parent, DN friend, IN public))	6	923
Escalation of smoking					
[199]	✓	Having a sibling who smokes was associated with an increase in cigarettes smoked per week (B=0.63, SE=0.22 p<.01).	SEM (A, BS, E, G, ITS, PB, TPB, N (DN parent, pressure friends))	24	1475
[202]	✓/×	Brother (r=.09, p<.05) but not sister (p>.05; statistics not reported) smoking was positively associated with initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses, but neither were associated with smoking in adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN friend, DN peer, IN parent, IN sibling, IN friend, pressure parents, pressure siblings, pressure friends))	9	504
[204]	✓/×	Sibling smoking was positively associated with escalation of smoking from two of seven stages only (immotive never smoker: w2=0.01; immotive experimental smoker: w2=0.02; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
[91]	×	The associations between all social norms and change in past-month smoking dissipated by emerging adulthood (p<.05, no statistics reported).	LogR (BS, fatalism, perceived discrimination, R, N (DN parent, DN peer, IN friend))	60	932

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
FAMILY/HOUSEHOLD SMOKING					
Initiation of smoking					
[206]	✓	Having a parent or sibling who smokes increased the odds of initiating any smoking (OR=1.70 [1.32-2.17]).	LogR (A, AP, G, MSE, PB, PS, RTA, school, SE, SES, N (DN friend, IN parent))	26	2603
[207]	✓	Having a parent or sibling who smokes was positively associated with initiation of any smoking in unadjusted analyses (statistics not reported; only unadjusted results reported).	Not stated	26	2596
[102]	✓/×	Having more household/family members who smoke increased the odds of initiating smoking from baseline never smoking or only puffing on a cigarette in unadjusted (p<.001; statistics not reported) but not adjusted (p>.05; statistics not reported) analyses.	LogR (A, FS, G, ITS, L, language, MH, SX, SES, N (DN friend, DN adult))	60	973
[152]	✓/×	Having two (OR=2.05 [1.37-3.06]) or at least three (1.90 [1.23-2.94]) family members who smoke, but not one (0.76 [0.51-1.13]), vs. none, increased the odds of initiating any smoking.	LogR (EC, G, ITS, SES, TBP, N (DN friend, IN general))	12	1726
[103]	✓/×	Having someone at home who smokes was positively associated with initiating any smoking in unadjusted (X^2= 4.32, p=.038) but not adjusted (OR=0.83 [0.65-1.06]) analyses.	X^2 and LogR (A, G, E, L, SE, TPB, N (DN friend))	36	2034
[146]	×	Having someone at home who smokes was not associated with initiating any smoking (OR=1.04 [0.52–2.06]).	LogR (AP, E, G, SES)	16	298
[211]	?	Not reported	Not reported		
Escalation of smoking					
[152]	✓	Having one (OR=1.69 [0.61-4.68]) two (1.41 [0.48-4.12]), or at least three (1.23 [0.45-3.41]) family members who smoke (vs. none) increased the odds of initiating rarely, occasional, or frequent smoking among baseline ever smokers.	LogR (EC, G, ITS, SES, TBP, N (DN friend, IN general))	12	318
[93]	✓	Having more family members who smoke increased the odds of past-term smoking initiation (OR=1.18 [1.02-1.36]).	LogR (BS, ITS, SX, TPB, N (DN friend, IN grouped))	3	620
[208]	×	Number of smoking family members was not associated with trajectories (X^2(12)=9.34, p>0.65)	X^2	8	193
[211]	?	Not reported	Not reported		
FRIEND SMOKING					
Initiation of smoking					
[146]	✓	Having at least one friend who smokes increased the odds of initiating any smoking (OR=2.58 [1.30–5.09]).	LogR (AP, E, G, SES)	16	298

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[103]	✓	Having more close friends who smoke was positively associated with initiating any smoking in unadjusted (t=4.02, p<.001) and adjusted (OR=1.20 [1.08-1.33]) analyses.	T-test and LogR (A, E, G, L, SE, TPB, N (DN Household/ Family))	36	2034
[152]	✓	Compared with having no friends who smoke, youth with a few (OR=1.87 [1.35-2.58]) or most (2.99 [1.52-5.87]) friends who smoke had greater odds of initiating any smoking.	LogR (EC, G, ITS, SES, TBP, N (DN family, IN general))	12	1726
[196]	✓	Those with any friends who smoke had greater risk of initiating any smoking (RR=1.87 [1.46–2.41]).	LogR (A, G, school)	26	2603
[1]	✓	Having friends who smoke increased the odds of initiating any smoking in unadjusted (OR=2.60 [1.34-5.07]) and adjusted (1.48 [0.66-3.34]) analyses.	LogR (A, AP, EC, ECN, G, ITS, PB, N (DN parent, DN sibling, IN public))	6	923
[101]	✓	All norms were directly related to initiating any smoking (no statistics reported).	Not stated	24	2541
[102]	✓	Having at least a few friends who smoke increased the odds of initiating smoking from baseline never smoking or only puffing on a cigarette in unadjusted (p<.001; statistics not reported) and adjusted (OR=1.73 [1.12-2.70]) analyses.	LogR (A, FS, G, ITS, L, language, MH, SX, SES, N (DN Household/Family, DN adult))	60	973
[197]	✓	Having any friends who smoke increased the odds of initiating established smoking (smoking >100 cigarettes in lifetime) in the minimally (RR=2.14 [1.63–2.80]) or fully (1.51 [1.06–2.16]) adjusted models.	GLM (minimally: A, G, school; fully: minimally + AP, MSE, PB, PS, RTA, SE, SES, N (DN parent, DN sibling, IN parent))	96	1791
[207]	✓/×	Having friends who smoke increased the odds of initiating any smoking in unadjusted (RR=1.8 [1.4-2.4]) but not adjusted (1.2 [0.9-1.5]) analyses.	LogR (A, AP, G, MSE, PS, RTA, SE, SES, N (DN, FS, IN parent))	26	2596
[104]	✓/×	Having a best friend who smokes increased the odds of initiating past-year any smoking in unadjusted (OR=5.86 [4.07-8.44]) but not adjusted (1.56 [0.91-2.68]) analyses. However, increases in best friend smoking between survey waves increased the odds of past-year any smoking (1.80 [1.13-2.88]).	LogR (PB, peer offers cigarettes, TPB, N (DN peer))	24	1654

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
[211]	✓/✗	Main effect of friend smoking not assessed. However, there was an interaction between peer smoking and perceived accessibility: compared to those with neither perceived accessibility nor friends who smoke, those with at least one smoking friend but no perceived accessibility (unadjusted: HR=5.60 [3.76-8.36]; adjusted: 4.04 [2.66-6.15]) and those with at least one smoking friend and perceived accessibility (unadjusted: 6.82 [4.53-10.29]; adjusted: 3.65 [2.26-5.9]) were more likely to initiate any smoking.	Survival analyses (A, concerns about weight, G, LS, PB, PS, N (DN parent, IN parent))	48	1027
[198]	✗	Best friends' smoking was not associated with initiating any smoking in unadjusted (OR=2.2 [0.7-6.1]) or adjusted (0.7 [0.2-2.8]) analyses.	LogR (FS, LS, R, TPB, N (DN parent, IN grouped, friend pressure))	18	442
[206]	✗	Having friends who smoke was not associated with initiating any smoking (OR=1.13 [0.88-1.46]).	LogR (A, AP, G, MSE, PB, PS, RTA, school, SE, SES, N (DN family, IN parent))	26	2603
[209]	✗	Neither number (model 1: OR=1.06 [0.90-1.25]; model 2: OR=0.99 [0.88-1.12]) nor proportion (model 1: 1.43 [0.69-2.95]; model 2: 1.00 [0.59-1.71]) of smoking friends was associated with initiating any smoking.	LogR (A, AP, BS [model 2 only], friendships, E, G, L, SES, N (DN peer, IN friends))	12	1950
[194]	✗	Having at least half of friends who smoke was not associated with at-least-monthly smoking initiation among girls (p>.05; statistics not reported) or boys (OR=1.90 [0.97-3.73]).	LogR (A, ITS, L, PB, R, SES, TPB, N (DN parent, IN parent, IN friend, pressure parents, pressure friends))	12	4055
		Escalation of smoking			
[193]	✓	Perceiving that a higher percentage of close friends smoke was negatively associated with escalation in number of cigarettes smoked per week (estimate=-0.01, SE=0.00, p=.001).	GCM (A, BS, E, G, MH, N (DN peer))	9	449
[93]	✓	More close friends who smoke increased the odds of past-term smoking (OR=1.43 [1.06-1.94]).	LogR (BS, ITS, SX, TPB, N (DN family, IN grouped))	3	620
[210]	✓	Having close friends who smoke seldom/sometimes (OR=1.85 [1.37-2.50]) or often/always (2.72 [1.72-4.31]) (vs. never) increased the odds of having higher levels of past-month smoking.	Ordinal LogR (BS, E, FS, G, MH, PB, PS, school, SES, N (IN parent))	48	2659
[200]	✓	Having a best friend who smokes (OR=2.35 [1.91-2.90]) and having over half of friends who smoke increased the odds of being an at-least-monthly smoker (OR=2.93 [2.32-3.69]).	LogR (A, BS, ED, G, N (DN parent))	14	6769

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[201]	✓	Compared with the non-smoking trajectory, having more friends who smoke increased the odds of being in all five other trajectories (trier: OR=1.68 [1.51-1.86]; occasional user: 2.66 [2.38-2.98]; early onset: 3.46 [3.06-3.92]; late onset: 2.13 [1.88-2.41]; decliner: 5.91 [4.96-7.05]). There was a significant association between friend smoking and trajectory group (X^2=604.02, p<.05).	LogR (A, E, FS, L, HSR, TIP, TPB, N (DN parent, DN peer, DN adult))	36	3637
[208]	✓/×	Spending time with people who smoke a lot (F(48,728)=1.01, p<0.45) and number of close high school friends who smoke (F(6,186)=1.39, p>0.20) were not associated with smoking trajectories, but frequency of being around friends while they smoke was (X^2(12)=23.11, p<0.03): a smaller proportion of small increasers and sporadic smokers reported that they were around friends while they were smoking 'a lot' compared to the remaining classes.	ANOVA and X^2	8	193
[152]	✓/×	Compared with having no friends who smoke, those with most (OR=3.23 [1.19-8.77]) but not a few (1.15 [0.50-2.66]) friends who smoke had greater odds of initiating rarely, occasional, or frequent smoking among baseline ever smokers.	LogR (EC, G, ITS, SES, TBP, N (DN family, IN general))	12	318
[92]	✓/×	As current friend smoking increased, smoking increased (M=.02, SD=.004, p<.001), but there was little evidence of an association between high school friend smoking and smoking (M=.0003, SD=.004, p>.05) among those who had ever tried smoking.	GCM (BS, G, relationship status, N (DN parent, DN partner, IN partner, IN friend))	9	779
[212]	✓/×	Having more close friends who smoke was positively associated with change in past-month smoking (ß=.10, p=.005), but when splitting results by gender this was only true in males (B=.17, p<.001) not females (B=-.01, p=.910).	MGLM (A, AP, BS, G, ITS, L, MH, PB, PS, SES, TPB, N (DN peer))	12	1158 3
[204]	✓/×	Perceiving that friends/people in the same school year smoke was positively associated with escalation of smoking from three of seven stages only (immotive never smoker: w2=0.01; immotive trier: w2=0.06; immotive nonsmoking decider: w2=0.02; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[202]	✓/×	Having more friends who smoke (r=0.11, p<.05) and a best friend who smokes (r=0.22, p<.05) were positively correlated with initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses, but neither were associated in adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN sibling, DN peer, IN parent, IN sibling, IN friend, pressure parents, pressure siblings, pressure friends)	9	504
[211]	✓/×	Main effect of friend smoking not assessed. However, there was peer smoking*perceived accessibility interaction: compared to those with neither perceived accessibility nor smoking friends, those with at least one smoking friend but no perceived accessibility (unadjusted: HR= 9.53 [4.92-18.47]; adjusted: 4.85 [2.35-10.02]) and those with at least one smoking friend and perceived accessibility (unadjusted: 27.63 [15.61-48.91]; adjusted: 8.27 [4.23-16.19) had greater odds of progressing from never or less-than-weekly smoking to at-least-weekly smoking.	Survival analyses (A, G, PB, PS, RTA, N (DN parent, IN parent))	48	1195
ROMANTIC PARTNER SMOKING					
Escalation of smoking					
[92]	✓	As romantic partner smoking increased, number of cigarettes smoked per day increased among those who had ever tried smoking (M=.01, SD=.01, p<.01).	GCM (BS, G, relationship status, N (DN parent, DN friend, IN partner, IN friend))	9	779
PERCEIVED PREVALENCE OF PEER SMOKING					
Initiation of smoking					
[101]	✓	All norms were directly related to smoking initiation (no statistics reported).	Not stated	24	2541
[213]	✓	Overestimating peer prevalence of smoking increased the odds of initiating any smoking in unadjusted (OR=2.04 [1.31–3.17]) and adjusted (1.79 [1.03–3.13]) analyses.	LogR (A, G, L, school, SHS, N (DN parent)	24	2171
[104]	✓/×	Perceiving a greater proportion of smoking peers increased the odds of initiating past-year any smoking in unadjusted (OR=5.99 [4.33-8.31]) but not adjusted (OR=1.66, CI=0.96-2.84) analyses. However, increases in perceiving a greater proportion of smoking peers between survey waves increased the odds of past-year any smoking (1.72 [1.16-2.57]).	LogR (PB, peer offers cigarettes, TPB, N (DN friend)	24	1654
[103]	×	Perceived prevalence of peer smoking was not associated with initiating any smoking in unadjusted (X^2=2.10, p=.349) or adjusted (statistics not reported) analyses.	X^2 and LogR (not stated)	36	2034

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
[209]	✗	Perceived prevalence of smoking among students the same age was not associated with initiating any smoking from baseline never smoking (model 1: OR=0.99 [0.92-1.05]) or any smoking among all smokers while controlling for baseline never vs. any smoking (model 2: OR=0.99 [0.94-1.04]).	LogR (A, AP, BS [model 2 only], friendships, E, G, L, SES, N (DN friend, IN friend)	12	1950
		Escalation of smoking			
[193]	✓	Perceiving that a higher percentage of university students smoke was positively associated with escalation in number of cigarettes smoked per week (estimate=0.003, SE=0.00, p=.041).	GCM (A, BS, E, G, MH, N (DN friend)	9	449
[200]	✓	Overestimating lifetime smoking among adolescents the same age increased the odds of being an at-least-monthly smoker (OR=1.43 [1.19-1.72])	LogR (A, G, ED, BS)	14	6769
[201]	✓	Compared with the non-smoking trajectory, perceptions that a higher number of teenagers of the same age smoke increased the odds of being in all five other trajectories (trier: OR=1.32 [1.18-1.48], occasional user: 1.93 [1.68-2.22], early onset: 2.11 [1.81, 2.47]; late onset: 1.58 [1.35-1.85]; decliner: 3.01 [2.43-3.72]). There was a significant association between perceived peer smoking and trajectory group (X^2=211.88, p<.05).	LogR (A, E, FS, L, HSR, TIP, TPB, N (DN parent, DN friend, DN adult))	36	3637
[203]	✓	Perceiving a higher percentage of smoking peers increased the odds of being a stable light/occasional (vs. non-smoker: OR=1.39 [1.2–1.6]) and accelerating (vs. non-smoker: 5.00 [2.96–8.44]; vs. stable light/occasional smoker: 3.6 [2.14–6.06]) smoker.	GCM (AP, FS, G, L, MH, PB, PS, school, SES, TPB, N (DN parent, IN parent, IN friend, IN teachers))	96	3521
[212]	✓/✗	Perceiving that more students your age smoke was positively associated with change in past-month smoking (ß=.11, p=.010) but when splitting results by gender this was not true in males (B=.09, p=.085) or females (B=.13, p=.059).	MGLM (A, AP, BS, G, ITS, L, MH, PB, PS, SES, TPB, N (DN friend))	12	1158 3
[204]	✓/✗	Perceiving that friends/people in the same school year smoke was positively associated with escalation of smoking from three of seven stages only (immotive never smoker: w2=0.01; immotive trier: w2=0.06; immotive nonsmoking decider: w2=0.02; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729

Table A3 continued below.

Table A3 (continued). Associations between descriptive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[202]	✓/×	Perceiving that more people in the same school year smoke was positively correlated with initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses (r=0.10, p<.05), but not adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN sibling, DN friend, IN parent, IN sibling, IN friend, pressure parents, pressure siblings, pressure friends))	9	504
[91]	×	The associations between all social norms and change in past-month smoking dissipated by emerging adulthood (p<.05, no statistics reported).	LogR (BS, fatalism, discrimination, R, N (DN parent, DN sibling, IN friend))	60	932
[208]	×	Perceived prevalence of smoking among students was not associated with smoking trajectories (F(48,760)=1.06, p< 0.36).	ANOVA	8	193
PERCEIVED PREVALENCE OF ADULT SMOKING					
Initiation of smoking					
[101]	✓	All norms were directly related to smoking initiation (no statistics reported).	Not stated	24	2541
[102]	✓	Perceiving that at least a few of your parents' friends smoke increased the odds of initiating smoking from baseline never smoking or only puffing on a cigarette in unadjusted (p<.001; statistics not reported) and adjusted (OR=1.38 [1.02-1.88]) analyses.	LogR (A, FS, G, ITS, L, language, MH, SX, SES, N (DN Household/Family, DN friend))	60	973
[103]	×	Perceived prevalence of adult smoking was not associated with initiating any smoking in unadjusted (X^2=1.56, p=.459) or adjusted (statistics not reported) analyses.	X^2 and LogR (not stated)	36	2034
Escalation of smoking					
[192]	✓	Perceiving that a greater proportion of adults smoke was associated with an increase in smoking stage (age 12.5-12.9: Coeff=0.05 [0.01-0.08]; age 13.0-13.4: 0.04 [0.01-0.06]; age 13.5-13.9: 0.03 [0.01-0.06]; age 14.0-14.4: 0.04 [0.02-0.06]; age 14.5-14.9: 0.03 [0.01-0.05]; age 15.0-15.4: 0.03 [0.01-0.05]; all p<.05).	Crosslagged mediation (A, BS, E, G, L, SES)	6	3112
[201]	✓	Compared with the non-smoking trajectory, perceptions that a higher number of adults smoke was increased the odds of being in all five other trajectories (trier: OR=1.36 [1.19-1.55]; occasional user: 1.70 [1.44-2.00]; early onset: 1.95 [1.62-2.34]; late onset: 1.33 [1.11-1.60]; decliner: 2.02 [1.58-2.59]). There was a significant association between perceived adult smoking and trajectory group (X^2= 96.24, p<.05).	LogR (A, E, FS, L, HSR, TIP, TPB, N (DN parent, DN friend, DN peer))	36	3637

Associations: ✓=Some evidence of associations (p<.05). ✓/×=Mixed evidence of associations. ×=Little evidence of associations (p≥.05). OR=Odds Ratio. [ ] = 95% confidence intervals. *Analysis:* ANOVA=Analysis of Variance, GCM=Growth Curve Models, LogR=Logistic Regression (or similar form, e.g. general linear model with log link), LinR=Linear Regression, MGLM=Multilevel Generalised Linear Model, SEM=Structural Equation Modelling, X^2=Chi Squared. *Covariates*: A=Age, AP=Academic Performance, BS=Baseline Smoking, E=Ethnicity, EC=Vaping, ECN=Vaping norms, FS=Family Structure/relationships, G=Gender, HSR=Home Smoking Restrictions, ITS=Intention/susceptibility To Smoke, L=Location, LS=Liking School/positive school experiences, MH=Mental Health, MSE=Movie Smoking Exposure, N=smoking Norms (DN=Descriptive Norm, IN=Injunctive Norm), PB=Problem Behaviour (includes alcohol/drug use, sensation-seeking, rebelliousness), PS=Parenting Style, R=Religion/culture, RTA=Receptivity to Tobacco Advertising, SE=Self-Esteem, SX=Smoking eXpectancies, SES=Socio-Economic Status, SHS=exposure to Second-Hand Smoke, TIP=Tobacco Industry Perceptions, TPB=Theory of Planned Behaviour measures (attitude, self-efficacy, perceived behavioural control, anticipated regret).

Table A4. Associations between injunctive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
		PERCEIVED PARENT APPROVAL OF SMOKING			
		Initiation of smoking			
[196]	✓	Those with neither/one parent (vs. both) who disapprove of smoking had greater risk of initiating any smoking (RR= 1.53 [1.16–2.01]).	LogR (A, G, school)	26	2603
[104]	✓/×	Perceiving less disapproval from parents increased the odds of initiating past-year any smoking among baseline past-year never smokers in unadjusted (OR=0.21 [0.15-0.30]) but not adjusted (statistics not reported) analyses.	LogR (not stated)	24	1654
[194]	✓/×	Perceiving that parents think you should not smoke decreased the odds of at-least-monthly smoking initiation among boys (OR=0.77 [0.62-0.96]) but not girls (p>.05; statistics not reported). However, social norm from parents only became a significant predictor for boys when both parent smoking and intention to smoke were included in the model.	LogR (A, ITS, L, PB, R, SES, TPB, N (DN parent, DN friend, IN friend, pressure parents, pressure friends))	12	4055
[195]	✓/×	Parent disapproval was associated with initiating any smoking (β=-0.18, p<.001) but when splitting by parent smoking this was only true among those with non-smoking parents (β=-0.17, p<0.001) and those with one smoking parent (β=-0.22, p<0.001) but not those with two smoking parents (statistics not reported).	SEM (A, ED, G, PS, N (DN parent))	24	4351
[207]	✓/×	Perceiving that neither/only one parent disapproves of smoking increased the odds of initiating any smoking in unadjusted (RR=1.5 [1.1-1.9]) but not adjusted (1.1 [0.8-1.4]) analyses.	LogR (A, AP, G, MSE, PS, RTA, SE, SES, N (DN family, DN friend))	26	2596
[215]	✓/×	Perceiving more approval of smoking from parents was positively directly associated with initiating any smoking in non-asthmatic (standardised coefficient=0.07, p<.01) but not asthmatic (statistics not reported) respondents. Perceiving more approval of smoking from parents was indirectly associated with initiating any smoking via intention to smoke in both non-asthmatic (standardised coefficient=0.05, p<.01) and asthmatic (standardised coefficient=0.14, p<.01) respondents.	SEM (TPB)	18	4079
[103]	×	Perceiving that smoking would bother parents a lot was not associated with initiating any smoking in either unadjusted (X^2=3.75, p=.053) but not adjusted (statistics not reported) analyses.	X^2 and LogR (not stated)	36	2034
[214]	×	Perceiving more favourable norms towards smoking from parents was not associated with initiating any smoking in unadjusted (OR=0.89, p>.05) or adjusted (OR=1.11, p>.05) analyses.	LogR (A, AP, E, G, ITS, LS, MH, PS, SX, SES, TPB, N (IN peer))	10	1137

Table A4 continued below.

Table A4 (continued). Associations between injunctive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
[197]	×	Compared with having both parents disapproving of smoking, having neither parents disapprove or mixed disapproval was not associated with initiating established smoking (smoking >100 cigarettes in lifetime) in analysis 1 RR=1.30 [0.95-1.78]) or 2 (RR=0.97 (0.71–1.34)).	LogR (minimally: A, G, school; fully: minimally + AP, MSE, PB, PS, RTA, SE, SES, N (DN parent, DN sibling, DN friend))	96	1791
[206]	×	Perceiving that neither/only one parent disapproves of smoking was not associated with initiating any smoking (OR=1.09 [0.83-1.43]).	LogR (A, AP, G, MSE, PB, PS, RTA, school, SE, SES, N (DN family, DN friend))	26	2603
[211]	?	Not reported	Not reported		
		Escalation of smoking			
[210]	✓	Perceiving that parents think it's important you don't smoke was negatively associated with higher levels of past-month smoking (OR=0.90 [0.85-0.94]).	Ordinal LogR (BS, E, FS, G, MH, PB, PS, school, SES, N (DN friend))	48	2659
[199]	✓	Perceiving that parents think you should smoke was positively associated with escalation in cigarettes smoked per week via intention to smoke (norm-intention path: B=0.21, SE=0.11, p<.05; intention-smoking path: B=0.27, SE=0.01, p<.001).	SEM (A, BS, E, G, ITS, PB, TPB, N (DN parent, DN sibling, IN sibling, IN friend, pressure friends))	24	1475
[202]	✓/×	Perceiving more approval of smoking from parents was positively correlated with initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses (r=0.14, p<.05), but not adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN sibling, DN friend, DN peer, IN sibling, IN friend, pressure parents, pressure siblings, pressure friends))	9	504
[204]	✓/×	Perceiving that parents think you should smoke was positively associated with escalation of smoking from two of seven stages only (contemplating experimenter: w2=0.03; committed nonsmoking decider: w2=0.01; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
[205]	✓/×	There was little evidence of an association between parent discussion (OR=0.75, p>.05) or punishment (OR=1.12, p>.05) and smoking escalation from being a never smoker or less-than-monthly smoker at baseline. However, there were parent smoking*discussion (χ2(1,380)=8.62, p<.003) and parent smoking*punishment (χ2(1,380)=6.09, p<.02) interactions: when both parents did not smoke, discussing smoking decreased the odds of smoking escalation (OR=0.41, p=.004), but when at least one parent smoked there was little evidence of an association between discussion and smoking escalation (OR=.98, p=.940). For smoking punishment, there were no effects in either subgroup (nonsmoking parents: OR=.79, p=.384; smoking parent: OR=1.39, p=.212).	LogR (analysis 1: A, BS, FS, SES, N (DN parent))	24	382

Table A4 continued below.

Table A4 (continued). Associations between injunctive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
[203]	✓/✗	Perceiving that parents would react badly if you smoked reduced the odds of being a stable light/occasional (vs. non-smoker: OR=0.57 [0.33–0.99]) but not an accelerating (vs. non-smoker: 0.44 [0.12–1.54]); vs. stable light/occasional: 0.77 [0.23–2.59]) smoker. Perceiving that parents agree with smoking increased the odds of being a stable light/occasional (vs. non-smoker: 0.66 [0.5–0.88]) and accelerating (vs. non-smoker: 0.29 [0.16–0.52]; vs. stable light/occasional: 0.43 [0.24–0.77]) smoker.	GCM (AP, FS, G, L, MH, PB, PS, school, SES, TPB, N (DN parent, DN peer, IN friend, IN teachers))	96	3521
[216]	✗	Parent approval of smoking was not associated with intention to smoke for either older (mother model: β=-.10, father model: β=-.16, both p>.05) or younger (mother: β=.18, father: β=.21, both p>.05) siblings (intention to smoke did subsequently predict higher smoking stage for older (mother: β=0.40, father: β=0.38, both p<.05) and younger (mother: β=0.32, father: β=0.35, both p<.05) siblings.	SEM (parent self-report smoking, parent communication about smoking, TPB, N (IN friend))	12	314
[211]	?	Not reported	Not reported		
		PERCEIVED SIBLING APPROVAL OF SMOKING			
		Escalation of smoking			
[199]	✓	Perceiving that siblings think respondent should smoke was positively associated with increase in cigarettes smoked per week via intention to smoke (norm-intention path: B=0.17, SE=0.07, p<.01; norm-smoking: B=0.27, SE=0.01, p<.001).	SEM (A, BS, E, G, ITS, PB, TPB, N (DN parent, DN sibling, IN parent, IN friend, pressure friends))	24	1475
[202]	✓/✗	Perceiving more approval of smoking from siblings was positively correlated with initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses (r=0.12, p<.05), but not adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN sibling, DN friend, DN peer, IN parent, IN friend, pressure parents, pressure siblings, pressure friends))	9	504
[204]	✓/✗	Perceiving that siblings think you should smoke was positively associated with escalation of smoking from two of seven stages only (immotive trier: w2=0.01; committed nonsmoking decider: w2=0.02; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
		PERCEIVED FRIEND/PEER APPROVAL OF SMOKING			
		Initiation of smoking			
[214]	✓/✗	Perceiving more favourable norms towards smoking from best friends and classmates increased the odds of initiating any smoking in unadjusted (OR=0.83, p<.001) but not adjusted (OR=0.89, p>.05) analyses.	LogR (A, AP, E, G, ITS, LS, MH, PS, SX, SES, TPB, N (IN parent))	10	1137

Table A4 continued below.

Table A4 (continued). Associations between injunctive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
[104]	✓/×	Perceiving less disapproval from friends increased the odds of initiating past-year any smoking among baseline past-year never smokers in unadjusted (OR=0.15 [0.11-0.22]) but not adjusted (statistics not reported) analyses.	LogR (not stated)	24	1654
[215]	✓/×	Perceiving more approval of smoking from friends/best friends was indirectly associated with initiating any smoking via intention to smoke in non-asthmatic (standardised coefficient=0.14, p<.001) but not asthmatic (statistics not reported) respondents.	SEM (TPB)	18	4079
[133]	✓/×	Perceiving that friends approve of smoking was associated with initiating any smoking via intention to smoke (norm-intention path: coef=.21, p<.05; intention-smoking: coef=.21, p<.05), but was not directly associated with initiating any smoking (p>.05; statistics not reported).	SEM (ITS, PS, TPB, N (DN parent))	6	1070
[146]	×	Having friends who are friendly towards smoking was not associated with initiating any smoking (OR=1.15 [0.63–2.10]).	LogR (AP, E, G, SES)	16	298
[194]	×	Perceiving that friends think you should smoke was not associated with at-least-monthly smoking initiation among girls or boys (both p>.05; statistics not reported).	LogR (A, ITS, L, PB, R, SES, TPB, N (DN parent, IN parent, DN friend, pressure parents, pressure friends))	12	4055
[211]	?	Not reported	Not reported		
		Escalation of smoking			
[92]	✓	As perceived approval of smoking from the three people you spend the most time with other than partner increased, number of cigarettes smoked per day increased (M=.01, SD=.003, p<.001) among those who had ever tried smoking.	GCM (BS, G, relationship status, N (DN parent, DN friend, DN partner, IN partner))	9	779
[203]	✓	Perceiving that friends would act badly if you smoked reduced the odds of being a stable light/occasional (vs. non-smoker: OR=0.59 [0.45-0.76]) and accelerating (vs. non-smoker: 0.28 [0.16–0.48]; vs. stable light/occasional: 0.47 [0.28–0.8]) smoker.	GCM (AP, FS, G, L, MH, PB, PS, school, SES, TPB, N (DN parent, DN friend, IN parent, IN teachers))	96	3521
[208]	✓	There was an association between perceived approval of smoking from the three people you spend the most time with other than partner and smoking trajectories (F(48,728)=1.59, p< 0.01). Perceived approval of smoking was higher among those with the highest levels of smoking at the beginning of the study (early decreasers) and there was a decline in perceived approval for most classes except large increasers and small increasers, who both showed an increase in smoking that was associated with an increase in close friend approval of smoking.	ANOVA	8	193

Table A4 continued below.

Table A4 (continued). Associations between injunctive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[204]	✓/×	Perceiving that friends/best friends/people in the same school year think you should smoke was positively associated with escalation of smoking from one of seven stages only (contemplating experimenter: w2=0.01; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
[216]	✓/×	Friends approval of smoking was positively associated with smoking stage via intention to smoke for older (norm-intention path: mother model: β=.47, father model: β=.51, both p<.05; intention-smoking: mother: β=0.40, father: β=0.38, both p<.05) but not younger (norm-intention: mother: β=.16, father: β=.14, both p>.05; intention-smoking: mother: β=0.32, father: β=0.35, both p<.05) siblings.	SEM (parent self-report smoking, parent communication about smoking, TPB, N (IN parent))	12	314
[202]	✓/×	Perceiving more approval of smoking from friends/best friend/people in the same school year was positively correlated with initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses (r=0.10, p<.05), but not adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN sibling, DN friend, DN peer, IN parent, IN sibling, pressure parents, pressure siblings, pressure friends))	9	504
[91]	×	The associations between all social norms and change in past-month smoking dissipated by emerging adulthood (p<.05, no statistics reported).	LogR (BS, fatalism, discrimination, R, N (DN parent, DN sibling, DN peer))	60	932
[199]	×	Perceiving that friends/best friend think respondent should smoke was not associated with intention to smoke (B=0.02, SE=0.06, p>.05), but intention to smoke was associated with an increase in cigarettes smoked per week (B=0.27, SE=0.01, p<.001).	SEM (A, BS, E, G, ITS, PB, TPB, N (DN parent, DN sibling, IN parent, IN sibling, pressure friends))	24	1475
[217]	×	Friends/best friends approval of smoking was not associated with escalation in smoking stage (β=0.06, p>.05).	LinR (BS, TPB)	12	612
[218]	×	Perceiving greater approval of smoking from friends/best friends was not associated with escalation in smoking stage from being a baseline ever smoker (OR=1.23 [0.96–1.56]).	LogR (A, AP, E, G, TPB)	12	397
[211]	?	Not reported	Not reported		
PERCEIVED PARTNER APPROVAL OF SMOKING					
Escalation of smoking					
[92]	✓	As perceived romantic partner approval of smoking increased, number of cigarettes smoked per day increased (M=.01, SD=.004, p<.05) among those who had ever tried smoking.	GCM (BS, G, relationship status, N (DN parent, DN friend, DN partner, IN friend)	9	779

Table A4 continued below.

Table A4 (continued). Associations between injunctive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[203]	✓/×	Perceiving that teachers would act badly if you smoked reduced the odds of being a stable light/occasional smoker (vs. non-smoker: OR=0.45 [0.26-0.77]), but not an accelerating smoker (vs. non-smoker: 0.62 [0.14-2.77]; vs. stable light/occasional: 1.38 [0.32–5.88]) smoker.	GCM (AP, FS, G, L, MH, PB, PS, school, SES, TPB, N (DN parent, DN friend, IN parent, IN friend))	96	3521
PERCEIVED APPROVAL OF SMOKING FROM IMPORTANT PEOPLE (GROUPED)					
Initiation of smoking					
[82]	✓	Perceiving more approval was associated with greater carbon monoxide levels in the least adjusted (β=0.45, SE=0.16, p<.01) and fully adjusted (β =0.38, SE=0.16, p<.05) models.	LinR (least: ITS, TPB; fully: ITS, SX, TPB)	24	674
[219]	✓/×	Perceiving that friends/best friend/family think you should not smoke was associated with initiation of any smoking in girls (β=0.55, SE=0.31, p<.05) but not boys (β=-0.28, SE=0.25, p>.05).	LogR (TPB)	48	497
[198]	×	Perceiving that teachers/friends/best friend think it's OK to smoke was not associated with initiation of any smoking in unadjusted (OR=1.1 [0.9-1.4]) or adjusted (1.0 [0.8-1.3]) analyses.	LogR (FS, LS, R, TPB, N (DN parent, DN friend, friend pressure))	18	442
[152]	×	Perceiving less acceptability of smoking from friends/best friend/family/important people was not associated with initiation of any smoking (OR=0.89 [0.57-1.39]).	LogR (EC, G, ITS, SES, TBP, N (DN family, DN friend))	12	1726
Escalation of smoking					
[220]	✓	Agreeing that people important to you think you should not smoke was positively associated with escalation in smoking stage via willingness to smoke (norm-willingness path: coeff=0.14, p≤.05; willingness-smoking: coeff=0.20, p≤.05) but not via intention to smoke (norm-intention: coeff=0.41, p≤.001; intention-smoking: t=1.20; p>.05).	SEM (BS, TPB)	12	760
[93]	×	Perceiving more approval was not associated with past-term smoking (OR=1.18 [0.73-1.92]).	LogR (BS, ITS, SX, TPB, N (DN family, DN friend))	3	620
[152]	×	Perceiving less acceptability of smoking from friends/best friend/family/ important people was not associated with initiation of rarely, occasional, or frequent smoking among baseline ever smokers (OR=1.12 [0.56-2.23]).	LogR (EC, G, ITS, SES, TBP, N (DN family, DN friend))	12	318
PERCEIVED SOCIETAL APPROVAL OF SMOKING					
Initiation of smoking					
[104]	✓/×	Perceiving less disapproval from the community increased the odds of initiating past-year any smoking in unadjusted (OR=0.21 [0.15-0.31]) but not adjusted (statistics not reported) analyses.	LogR (not stated)	24	1654

Table A4 continued below.

Table A4 (continued). Associations between injunctive norms and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
[1]	×	Perceived public approval of smoking was not associated with initiating any smoking in unadjusted (OR=2.45 [0.60-9.96]) or adjusted (1.33 [0.34-5.16]) analyses.	LogR (A, AP, EC, ECN, G, ITS, PB, N (DN parent, DN sibling, DN friend))	6	923

Associations: ✓=Some evidence of associations (p<.05). ✓/×=Mixed evidence of associations. ×=Little evidence of associations (p≥.05). OR=Odds Ratio. [ ] = 95% confidence intervals. *Analysis:* ANOVA=Analysis of Variance, GCM=Growth Curve Models, LogR=Logistic Regression (or similar form, e.g. general linear model with log link), LinR=Linear Regression, MGLM=Multilevel Generalised Linear Model, SEM=Structural Equation Modelling, X^2=Chi Squared. *Covariates*: A=Age, AP=Academic Performance, BS=Baseline Smoking, E=Ethnicity, EC=Vaping, ECN=Vaping norms, FS=Family Structure/relationships, G=Gender, ITS=Intention/susceptibility To Smoke, L=Location, LS=Liking School/positive school experiences, MH=Mental Health, MSE=Movie Smoking Exposure, N=smoking Norms (DN=Descriptive Norm, IN=Injunctive Norm), PB=Problem Behaviour (includes alcohol/drug use, sensation-seeking, rebelliousness), PS=Parenting Style, R=Religion/culture, RTA=Receptivity to Tobacco Advertising, SE=Self-Esteem, SX=Smoking eXpectancies, SES=Socio-Economic Status, TPB=Theory of Planned Behaviour measures (attitude, self-efficacy, perceived behavioural control, anticipated regret).

Table A5. Associations between perceived pressure to smoke and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref	Association between norm and smoking as presented in article		Analysis (variables adjusted for)	Follow-up (months)	N
PERCEIVED PRESSURE TO SMOKE FROM PARENTS					
Initiation of smoking					
[194]	×	Perceiving pressure to smoke from parents was not associated with at-least-monthly smoking for either girls (OR=0.85 [0.67-1.09]) or boys (p>.05; statistics not reported).	LogR (A, ITS, L, PB, R, SES, TPB, N (DN parent, DN friend, IN parent, IN friend, pressure friends))	12	4055
Escalation of smoking					
[202]	✓/×	Perceiving more pressure to smoke from parents was positively correlated with smoking initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses (r=0.17, p<.05), but not adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN sibling, DN friend, DN peer, IN parent, IN sibling, IN friend, pressure siblings, pressure friends))	9	504
[204]	×	Perceiving pressure to smoke from parents was not associated with escalation from any of the seven smoking stages (statistics not reported) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
PERCEIVED PRESSURE TO SMOKE FROM SIBLINGS					
Escalation of smoking					
[202]	✓/×	Perceiving more pressure to smoke from siblings was positively correlated with smoking initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses (r=0.16, p<.05), but not adjusted regression analyses (statistics not reported).	Correlation and LogR (AP, FS, G, ITS, PB, SES, TPB, N (DN parent, DN sibling, DN friend, DN peer, IN parent, IN sibling, IN friend, pressure parents, pressure friends))	9	504
[204]	×	Perceiving pressure to smoke from siblings was not associated with escalation from any of the seven smoking stages (statistics not reported) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
PERCEIVED PRESSURE TO SMOKE FROM FRIENDS/PEERS					
Initiation of smoking					
[198]	✓/×	Perceived pressure to smoke by friends/best friends/other adolescents increased the odds of initiating any smoking in adjusted (OR=1.8 [1.0-3.2]) but not unadjusted (1.6 [0.9-2.7]) analyses.	LogR (FS, LS, R, TPB, N (DN parent, DN friend, IN grouped))	18	442
[194]	✓/×	Perceiving pressure to smoke from friends increased the odds of at-least-monthly smoking initiation among girls (OR=1.26 [1.11-1.42]) but not boys (1.10 [0.96-1.26]).	LogR (A, ITS, L, PB, R, SES, TPB, N (DN parent, DN friend, IN parent, IN friend, pressure parents))	12	4055

Table A5 continued below.

Table A5 (continued). Associations between perceived pressure to smoke and smoking initiation and escalation. Abbreviations are defined in footnote.

Ref		Association between norm and smoking as presented in article	Analysis (variables adjusted for)	Follow-up (months)	N
		Escalation of smoking			
[202]	✓	Perceiving more pressure to smoke from friends/best friend/people in same school year was positively correlated with smoking initiation of at-least-weekly smoking from baseline less-than-weekly smoking in unadjusted correlation analyses (r=0.22, p<.05) and adjusted regression analyses (model 1: OR=1.86; model 2: OR=1.57, both p<.05).	Correlation and LogR (AP, FS, G, [ITS: model 2 only], PB, SES, TPB, N (DN parent, DN sibling, DN friend, DN peer, IN parent, IN sibling, IN friend, pressure parents, pressure siblings))	9	504
[204]	✓/×	Perceiving pressure to smoke from friends/best friends/people in the same school year was positively associated with escalation of smoking from one of seven stages only (immotive never smoker: w2=0.01; no other stages significant) from baseline less-than-weekly smoking.	ANOVA (A, G, L)	12	6729
[199]	×	Perceiving pressure to smoke from friends/best friend was not associated with an increase in cigarettes smoked per week (B=0.31, SE=0.16, p>.05).	SEM (A, BS, E, G, ITS, PB, TPB, N (DN parent, DN sibling, IN parent, IN sibling, IN friend))	24	1475

Associations: ✓=Some evidence of associations (p<.05). ✓/×=Mixed evidence of associations. ×=Little evidence of associations (p≥.05). OR=Odds Ratio. [ ] = 95% confidence intervals. *Analysis:* LogR=Logistic Regression (or similar form, e.g. general linear model with log link), SEM=Structural Equation Modelling, X^2=Chi Squared. *Covariates*: A=Age, AP=Academic Performance, BS=Baseline Smoking, E=Ethnicity, ITS=Intention/susceptibility To Smoke, L=Location, LS=Liking School/positive school experiences, MH=Mental Health, MSE=Movie Smoking Exposure, N=smoking Norms (DN=Descriptive Norm, IN=Injunctive Norm), PB=Problem Behaviour (includes alcohol/drug use, sensation-seeking, rebelliousness), R=Religion/culture, SES=Socio-Economic Status, TPB=Theory of Planned Behaviour measures (attitude, self-efficacy, perceived behavioural control, anticipated regret).

Appendix G. Supplementary data for Chapter 4

Table A6 (referred to as Table A1 in the publication in Chapter 4). Description of smoking status, e-cigarette status, and demographic and psychosocial covariates. Italics indicate notes that were not included in the item wording.

Variable	Item(s) and response options	Coding
Smoking status	Which ONE of the following BEST applies to you? 1. I have never smoked cigarettes, not even a puff or two 2. I have only ever tried smoking cigarettes once 3. I have tried smoking cigarettes more than once but only a few times 4. I used to smoke sometimes but I never smoke cigarettes now 5. I sometimes smoke cigarettes now but less than once a month 6. I usually smoke cigarettes at least once a month but less than once a week *(due to an error in the survey this was only assessed at W2)* 7. I usually smoke between one and six cigarettes a week 8. I usually smoke more than six cigarettes a week 9. Prefer not to say	**Never smoker** (1) **Ever smoker** (2-8) **Smoking escalation** (baseline: 1 and follow-up: 2-8, or baseline: 2 and follow-up: 3, or baseline: 2 and follow-up: 5-8, or baseline: 3 and follow-up: 5-8, or baseline: 4 and follow-up: 5-8, or baseline: 5 and follow-up: 6-8, or baseline: 7 and follow-up: 8) **No smoking escalation** all other combinations Excluded = 9
E-cigarette status	(a) Have you ever heard of e-cigarettes? They are also sometimes called shisha pens, vaporisers or electronic cigarettes. 1. Yes, I have 2. No, I haven't 3. Don't know *[Those who responded "Yes, I have" to the above were then asked:]* (b) Which ONE of the following is closest to describing your experience of e-cigarettes? 1. I have never used an e-cigarette 2. I have only used an e-cigarette once 3. I have used an e-cigarette more than once but only a few times 4. I used to use e-cigarettes but I do not use e-cigarettes now 5. I use e-cigarettes sometimes, but no more than once a month 6. I use e-cigarettes more than once a month, but less than once a week 7. I use e-cigarettes more than once a week but not every day 8. I use e-cigarettes every day 9. Prefer not to say 10. Don't know	**Never user** ((a) 1 and (b) 1) **Ever user** ((a) 1 and (b) 2-8) **E-cigarette escalation** (a) 1 and (b) baseline: 1 and follow-up: 2-8, or baseline: 2 and follow-up: 3, or baseline: 2 and follow-up: 5-8, or baseline: 3 and follow-up: 5-8, or baseline: 4 and follow-up: 5-8, or baseline: 5 and follow-up: 6-8, or baseline: 6 and follow-up: 7-8 or baseline: 7 and follow-up: 8) **No e-cigarette escalation** all other combinations Excluded = (a) 2, 3 or (b) 9, 10

Table A6 continued below.

Table A6 (continued; referred to as Table A1 in the publication in Chapter 4). Description of smoking status, e-cigarette status, and demographic and psychosocial covariates. Italics indicate notes that were not included in the item wording.

Variable	Item(s) and response options	Coding
Age	(a) *Adult initially answering survey:* And which of these age groups do you fall into? 1. Under 16 2. 16-18 3. 19-24 4. 25-34 5. 35-44 6. 45-54 7. 55-56 8. Over 65 (b) *If (a) 3-8:* Which, if any, of the following apply to you? PLEASE SELECT ALL THAT APPLY. I am the parent or legal guardian of a child / children aged … 1. 11-13 that live(s) with me 2. 14-15 that live(s) with me 3. None of the above 4. Prefer not to say	**11-13** ((a) 3-8 and (b) 1) **14-15** ((a) 3-8 and (b) 2) **16-18** ((a) 2) Excluded = (a) 1 or (b) 3-4
Gender	Are you... 1. Male 2. Female	**Male** (1) **Female** (2)
School performa-nce	How would you describe your grades last year, or in the last year of school that you attended? 1. Excellent 2. Good 3. Average 4. Below average 5. Don't know 6. Prefer not to say	**Continuous between 1 and 4,** recoded so that 1 = below average, 4 = excellent Excluded = 5-6
Problem behaviour	(a) I get in trouble in school/I used to get in trouble at school. 1. Not at all like me 2. A little like me 3. Pretty much like me 4. Exactly like me 5. Don't know 6. Prefer not to say (b) I do things my parent(s) (or carer(s)) wouldn't want me to do. 1. Not at all like me 2. A little like me 3. Pretty much like me 4. Exactly like me 5. Don't know 6. Prefer not to say	**Added the scales to form a continuous scale between 2-8**, with 8 = greater problem behaviour Excluded = 5-6 to (a) or (b)

Table A6 continued below.

Table A6 (continued; referred to as Table A1 in the publication in Chapter 4). Description of smoking status, e-cigarette status, and demographic and psychosocial covariates. Italics indicate notes that were not included in the item wording.

Variable	Item(s) and response options	Coding
Monthly alcohol use	How often do you have an alcoholic drink, if at all? 1. I never drink alcoholic drinks 2. Every day or almost every day 3. About twice a week 4. About once a week 5. About once a fortnight 6. About once a month 7. Only a few times a year 8. About once a year 9. Don't know 10. Prefer not to say	**Yes** (2-6) **No** (1,7-8) Excluded = 9-10
Smoking susceptibi-lity	(a) If one of your friends offered you a tobacco cigarette, would you try it? 1. Definitely yes 2. Probably yes 3. Probably no 4. Definitely no 5. Prefer not to say (b) Do you think that you will try a cigarette sometime in the next year? 1. Definitely yes 2. Probably yes 3. Probably no 4. Definitely no 5. Prefer not to say	**Not susceptible** (4 to (a) and (b)) **Susceptible** (1-3 to (a) or (b)) Excluded = 5 to (a) or (b)
E-cigarette susceptibi-lity	(a) If one of your friends offered you an e-cigarette, would you try it? 1. Definitely yes 2. Probably yes 3. Probably no 4. Definitely no 5. Prefer not to say (b) Do you think that you will try an e-cigarette sometime in the next year? 1. Definitely yes 2. Probably yes 3. Probably no 4. Definitely no 5. Prefer not to say	**Not susceptible** (4 to (a) and (b)) **Susceptible** (1-3 to (a) or (b)) Excluded = 5 to (a) or (b)
Some friends smoke	Do any of these people that you know smoke tobacco cigarettes? (a) Some friends of my own age 1. Yes 2. No 3. Not applicable 4. Don't know (b) Some friends older than me. 1. Yes 2. No 3. Not applicable 4. Don't know (c) Some friends younger than me. 1. Yes 2. No 3. Not applicable 4. Don't know	**Yes** (1 to either (a), (b) or (c)) **No** (2 to (a), (b) and (c) OR 2 for either (a), (b) or (c) but 3 for the rest) **Not applicable/don't know** was included as a separate response option due to the large number who selected other combinations (3 or 4 for (a), (b) and (c))

Table A6 continued below.

Table A6 (continued; referred to as Table A1 in the publication in Chapter 4). Description of smoking status, e-cigarette status, and demographic and psychosocial covariates. Italics indicate notes that were not included in the item wording.

Variable	Item(s) and response options	Coding
Some friends use e-cigarettes	Do any of these people that you know use e-cigarettes? (a) Some friends of my own age. 1. Yes 2. No 3. Not applicable 4. Don't know (b) Some friends older than me. 1. Yes 2. No 3. Not applicable 4. Don't know (c) Some friends younger than me. 1. Yes 2. No 3. Not applicable 4. Don't know	**Yes** (1 to either (a), (b) or (c)) **No** (2 to (a), (b) and (c) OR 2 for either (a), (b) or (c) but 3 for the rest) **Not applicable/don't know** was included as a separate response option due to the large number who selected other combinations (3 or 4 for (a), (b) and (c))
At least one parent smokes	Do any of these people that you know smoke tobacco cigarettes? (a) Mother (or female carer) 1. Yes 2. No 3. Not applicable 4. Don't know (b) Father (or male carer) 1. Yes 2. No 3. Not applicable 4. Don't know	**Yes** (1 to either (a) or (b)) **No** (all other response combinations, due to the small number of respondents who selected 3 and 4)
At least one parent uses e-cigarettes	Do any of these people that you know use e-cigarettes? (a) Mother (or female carer) 1. Yes 2. No 3. Not applicable 4. Don't know (b) Father (or male carer) 1. Yes 2. No 3. Not applicable 4. Don't know	**Yes** (1 to either (a) or (b)) **No** (all other response combinations, due to the small number of respondents who selected 3 and 4)
Sibling(s) smoke	Do any of these people that you know smoke tobacco cigarettes? Brother or sister. 1. Yes 2. No 3. Not applicable 4. Don't know	**Yes** (1) **No** (2) **Not applicable/don't know** was included as a separate response option due to the large number who selected other combinations (3 or 4)

Table A6 continued below.

Table A6 (continued; referred to as Table A1 in the publication in Chapter 4). Description of smoking status, e-cigarette status, and demographic and psychosocial covariates. Italics indicate notes that were not included in the item wording.

Variable	Item(s) and response options	Coding
Sibling(s) use e-cigarettes	Do any of these people that you know use e-cigarettes? Brother or sister. 1. Yes 2. No 3. Not applicable 4. Don't know	**Yes** (1) **No** (2) **Not applicable/don't know** was included as a separate response option due to the large number who selected other combinations (3 or 4)
Public approval of smoking	In your opinion, do the general public approve or disapprove of people your age smoking tobacco cigarettes? 1. Strongly approve 2. Approve 3. Neither approve nor disapprove 4. Disapprove 5. Strongly disapprove 6. Don't know	**Yes** (1-2) **No** (3-6)
Public approval of e-cigarettes	In your opinion, do the general public approve or disapprove of people your age using e- cigarettes? 1. Strongly approve 2. Approve 3. Neither approve nor disapprove 4. Disapprove 5. Strongly disapprove 6. Don't know	**Yes** (1-2) **No** (3-6)

Appendix H. Letter to the editor and invited response (re: Chapter 4)

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Letter to the editor

When Authors Do Not Like Their Data

To the editor:

I read with interest the paper by East and colleagues showing an association between e-cigarette use and later cigarette smoking in a cohort of 11–18-year olds in Great Britain [1]. The authors lay down in the introduction the rationale for the current study based on the limitation of current literature about the relationship between e-cigarette use and cigarette initiation including: inadequate study design and analysis for causal inference, evidence of two directional association between e-cigarettes and cigarette smoking, and lack of accounting of extraneous factors that may be related to both smoking and e-cigarette use [1]. So in order to clarify these issues, the authors conducted a prospective (cohort) study that is known to be powerful for establishing causality for behavioral risk factors, especially as they combined it with the application of a causal analytical framework and adjustment for several factors known to influence tobacco/nicotine use in youth [1]. Still, for the most part, the authors do not make any causal inference of their results, but expressed the increased probability of later cigarette initiation among ever e-cigarettes users as "prospective association," or "two-way association," rather than risk of initiation or within a clear causal interpretation [1,2]. The fact that the "association" between e-cigarettes and cigarette smoking worked in both ways, yet it was stronger from e-cigarettes to cigarettes, does not preclude causality. Relationships between risks (causes) and outcomes can be complex, nonlinear, and multidirectional [3]. For example, obesity leads to joint stress, and joint problems potentiate obesity through reduced movement. Which comes first and how they interact at different stages is a dynamic rather than static relationship. The wide availability and aggressive marketing of e-cigarettes to youth, their low price, and their "low-risk" appeal make them a strong contender as the first nicotine drug on the cascade to diverse nicotine products currently available to youth. But rather than entertaining this scenario, the authors engage in a sort of scientific "acrobatics" to interpret their results without making any causal inference. One possible explanation for such approach is that members of this study team have argued strongly in the past against the potential of e-cigarettes as a gateway to cigarette smoking [4,5]. Science is about constantly reexamining our assumptions based on new knowledge, rather than examining new knowledge based on our preformed assumptions.

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The Authors reply:

The letter [1] criticized our paper on the association between smoking and e-cigarette use among young people [2] for avoiding causal terminology. While we agree our study had considerable strengths, including causal mediation analyses [3], these do not enable us to conclude that trying e-cigarettes causes someone to become a dependent smoker (the so-called "gateway" effect).

In causal inference literature, Daniel et al. [4] argued that an "ideal" study would have at least: (i) no inclusion/exclusion criteria, (ii) large sample size, (iii) unambiguously defined exposure levels allocated at random, (iv) long follow-up, (v) rich

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covariate data, and (vi) no attrition, missing data, noncompliance, or measurement error. In some contexts, observational studies, rather than randomized controlled trials, are more feasible, ethical and practical [4]; this is the case with youth e-cigarette and smoking behaviors. We can then use causal mediation analyses [3] to investigate specific pathways with such observational studies. Although we found a direct causal effect of trying an e-cigarette on trying smoking [2], our study is limited in terms of (ii), (iv), (v), and (vi) to conclude a "gateway" effect. Indeed, we have argued against the term "gateway," until it is clearer how this could be tested [5].

We also observed a direct causal effect of trying smoking on trying an e-cigarette [2] and although we adjusted for some confounders, there are likely additional common liabilities [6,7] contributing to both associations. Our study suffered high attrition and low numbers of smokers and particularly e-cigarette users. This necessitated focusing on ever, rather than regular, users for exposures and outcomes. As only 21 baseline never smokers had tried an e-cigarette (vs. 118 never e-cigarette users who had tried smoking), we disagree that e-cigarettes are "a strong contender as the first nicotine drug on the cascade to diverse nicotine products..." [1]. Further studies are required to eliminate the influence of common liabilities, study design, or sample selection. The importance of using multiple approaches (i.e., triangulation) when inferring causality has been emphasized elsewhere [8].

We are disappointed that the author(s) [1] suggest scientific "acrobatics" and urge for inappropriate conclusions. Our language is appropriately cautious given the study's limitations, while acknowledging its strengths and the different contexts for the two products. We agree that good scientific practice entails reexamination of assumptions and revisions of knowledge, which is why we continue to study these issues, but it also involves appropriate understanding and communication of the data and their limitations.

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Appendix I. Supplementary Data for Chapter 8

Table A7 (referred to as Supplementary Table 1 in the publication in Chapter 8). Unadjusted cross-sectional prevalence of all covariates, by Wave (N=57,086 observations from 23,831 respondents). Data are weighted. W=Wave.

	W1 **2002**	**W2** **2003**	**W3** **2004**	**W4** **2005-2006**	**W5** **2006-2007**	**W6** **2007-2008**	**W7** **2008-2009**	**W8** **2010-2011**	**W9** **2013-2015**
Age (%)									
18-24	14.82	12.34	11.34	10.19	9.10	8.51	7.33	6.29	7.86
25-39	32.65	30.84	29.52	29.35	29.90	28.94	27.38	25.59	27.12
40-54	33.34	35.77	37.32	38.00	38.34	38.78	39.97	40.89	37.47
55-max	19.19	21.06	21.82	22.46	22.66	23.77	25.31	27.22	27.55
Gender: Female (%)	46.62	47.53	48.67	48.63	49.00	48.65	48.19	48.64	47.16
Ethnicity: Majority (%)	87.03	87.83	88.78	89.14	88.86	89.16	89.95	90.03	87.28
Income (%)									
Low	29.53	29.52	29.19	30.03	29.93	27.33	27.04	27.62	33.21
Moderate	35.39	34.85	35.72	34.37	33.30	33.46	31.68	31.35	29.98
High	27.33	28.24	28.72	29.17	29.81	32.24	33.31	32.77	30.74
No answer	7.75	7.38	6.37	6.42	6.96	6.97	7.97	8.27	6.07
Education (%)									
Low	57.46	54.91	54.72	54.20	54.64	52.21	51.87	50.24	46.35
Moderate	31.21	33.79	32.31	30.89	30.36	31.88	31.39	32.57	34.84
High	10.90	10.99	12.55	14.56	14.71	15.70	16.47	16.85	18.24
No answer	0.43	0.32	0.42	0.35	0.29	0.22	0.27	0.34	0.57
HSI (mean (SE))	2.89 (0.02)	2.76 (0.02)	2.81 (0.02)	2.73 (0.02)	2.82 (0.02)	2.83 (0.02)	2.82 (0.02)	2.94 (0.03)	2.65 (0.03)
Survey mode: Internet (%)	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	2.12	29.84	67.10
Time-in-sample (mean (SE))	1.00 (0.00)	1.78 (0.01)	2.18 (0.01)	2.60 (0.02)	2.69 (0.02)	2.90 (0.03)	3.42 (0.03)	4.04 (0.04)	2.86 (0.04)
Time-between-Waves (mean (SE))	0.00 (0.00)	0.44 (0.00)	0.70 (0.01)	0.88 (0.01)	0.61 (0.01)	0.61 (0.01)	0.85 (0.01)	1.36 (0.01)	1.18 (0.02)

HSI=Heaviness of Smoking Index. SE=standard error. *Internet surveys were only introduced from Wave-7 (2008-2009).

Table A8 (referred to as Supplementary Table 2 in the publication in Chapter 8. Unadjusted cross-sectional prevalence of (i) having over half of five closest friends smoke, (ii) agreeing that people important to you believe you should not smoke, (iii) agreeing that society disapproves of smoking, and (iv) having a negative opinion of smoking, by country and Wave (N=57,086 observations from 23,831 respondents). Data are weighted. W=Wave.

	W1 2002	W2 2003	W3 2004	W4 2005-2006	W5 2006-2007	W6 2007-2008	W7 2008-2009	W8 2010-2011	W9 2013-2015
(i) Over half of five closest friends smoke (%)									
Canada	58.87	56.93	57.64	52.19	53.00	52.24	51.62	50.07	50.54
US	60.63	58.57	60.52	57.97	58.20	56.50	52.23	53.27	55.76
UK	60.59	61.39	54.86	52.77	53.92	54.67	52.37	50.78	46.87
Australia	59.71	56.91	55.35	53.53	50.38	53.50	51.65	48.43	52.18
Total	**59.96**	**58.43**	**57.14**	**54.12**	**53.86**	**54.21**	**51.97**	**50.67**	**52.30**
(ii) Agree that people important to you believe you should not smoke (%)									
Canada	89.71	86.01	88.18	90.81	89.60	89.23	87.45	86.08	85.54
US	89.50	88.59	89.04	90.32	91.06	88.15	86.83	87.49	75.71
UK	85.46	79.19	82.84	84.12	85.02	80.95	78.85	77.75	71.98
Australia	88.73	87.61	87.60	89.99	89.06	85.86	85.23	82.92	76.69
Total	**88.27**	**85.35**	**86.94**	**88.84**	**88.72**	**86.09**	**84.56**	**83.89**	**77.25**
(iii) Agree that society disapproves of smoking (%)									
Canada	88.37	88.47	89.61	91.03	90.02	91.55	88.46	85.84	80.80
US	78.93	80.66	82.80	84.53	86.22	85.99	85.66	80.90	67.76
UK	77.34	80.26	83.43	85.69	86.77	85.27	83.93	82.31	75.14
Australia	81.68	82.70	87.88	87.23	88.71	88.14	83.92	80.07	78.27
Total	**81.51**	**83.08**	**85.91**	**87.14**	**87.94**	**87.77**	**85.54**	**82.34**	**73.78**
(iv) Negative opinion of smoking									
Canada (%)	62.43	56.66	54.64	57.76	56.67	56.58	54.05	48.74	58.68
US	52.75	48.19	51.10	50.58	49.92	50.03	48.49	46.35	45.18
UK	47.93	44.52	45.66	51.49	47.38	46.13	44.42	40.81	45.80
Australia	55.81	51.30	52.25	53.40	54.34	51.16	53.61	50.36	52.15
Total	**54.59**	**50.24**	**50.93**	**53.33**	**52.12**	**51.02**	**50.09**	**46.80**	**49.37**

Table A9 (referred to as Supplementary Table 3 in the publication in Chapter 8). Adjusted associations between all model variables and (i) having over half of five closest friends smoke, (ii) agreeing that people important to you believe you should not smoke, (iii) agreeing that society disapproves of smoking, and (iv) having a negative opinion of smoking, among daily smokers (N=57,086 observations from 23,831 respondents).

	(i) Over half of five closest friends smoke		(ii) Agree that people important to you believe you should not smoke		(iii) Agree that society disapproves of smoking		(iv) Negative opinion of smoking	
	AOR (95% CI)	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**
Wave								
1 - 2002 (ref)	1.00		1.00		1.00		1.00	
2 - 2003	1.04 (0.98-1.10)	.250	**0.71 (0.65-0.78)**	**<.001**	1.03 (0.94-1.12)	.557	**0.86 (0.81-0.91)**	**<.001**
3 - 2004	1.03 (0.96-1.10)	.477	**0.77 (0.69-0.86)**	**<.001**	**1.22 (1.11-1.35)**	**<.001**	**0.88 (0.82-0.94)**	**<.001**
4 - 2005-2006	0.98 (0.92-1.06)	.673	0.90 (0.81-1.01)	.072	**1.31 (1.18-1.47)**	**<.001**	0.97 (0.91-1.04)	.423
5 - 2006-2007	1.00 (0.93-1.08)	.998	0.92 (0.82-1.04)	.178	**1.38 (1.24-1.55)**	**<.001**	**0.93 (0.86-1.00)**	**.045**
6 - 2007-2008	1.06 (0.98-1.15)	.137	**0.73 (0.65-0.83)**	**<.001**	**1.32 (1.17-1.48)**	**<.001**	**0.89 (0.82-0.96)**	**.002**
7 - 2008-2009	1.04 (0.95-1.13)	.433	**0.62 (0.55-0.71)**	**<.001**	1.06 (0.94-1.20)	.314	**0.86 (0.79-0.94)**	**.001**
8 - 2010-2011	1.02 (0.92-1.13)	.747	**0.67 (0.57-0.78)**	**<.001**	0.89 (0.77-1.03)	.130	**0.83 (0.75-0.91)**	**<.001**
9 - 2013-2015	0.95 (0.85-1.07)	.436	**0.54 (0.46-0.64)**	**<.001**	**0.74 (0.63-0.87)**	**<.001**	1.04 (0.93-1.17)	.503
Country								
Canada (ref)	1.00		1.00		1.00		1.00	
US	**1.10 (1.03-1.19)**	**.007**	0.99 (0.89-1.10)	.822	**0.63 (0.57-0.69)**	**<.001**	**0.71 (0.66-0.77)**	**<.001**
UK	1.03 (0.96-1.11)	.453	**0.58 (0.52-0.64)**	**<.001**	**0.59 (0.54-0.65)**	**<.001**	**0.66 (0.62-0.71)**	**<.001**
Australia	0.94 (0.87-1.02)	.131	**0.84 (0.75-0.94)**	**.003**	**0.74 (0.67-0.82)**	**<.001**	**0.88 (0.81-0.95)**	**.001**
Age								
18-24 (ref)	1.00		1.00		1.00		1.00	
25-39	**0.54 (0.48-0.60)**	**<.001**	**1.15 (1.00-1.33)**	**.045**	**1.62 (1.45-1.81)**	**<.001**	**1.20 (1.08-1.32)**	**<.001**
40-54	**0.34 (0.31-0.38)**	**<.001**	**1.26 (1.09-1.45)**	**.001**	**2.46 (2.20-2.75)**	**<.001**	**1.15 (1.04-1.27)**	**.003**
55-max	**0.22 (0.20-0.25)**	**<.001**	1.00 (0.86-1.16)	.954	**2.44 (2.17-2.74)**	**<.001**	0.98 (0.89-1.08)	.766
Gender								
Female	1.00		1.00		1.00		1.00	
Male	**1.05 (1.00-1.11)**	**.041**	**0.86 (0.79-0.92)**	**<.001**	**0.68 (0.63-0.72)**	**<.001**	1.04 (0.99-1.10)	.094

HSI=Heaviness of Smoking Index. AOR=Adjusted Odds Ratio, adjusted for all variables in the model. 95% CI=95% confidence interval. 95% CIs are reported to 3 decimal places where they are close to 1.00 (±0.005). Linear, quadratic, and cubic terms for Wave (presented in Table 2 in the manuscript body) are not included here as these terms were added the model as an additional step (see Analyses section).

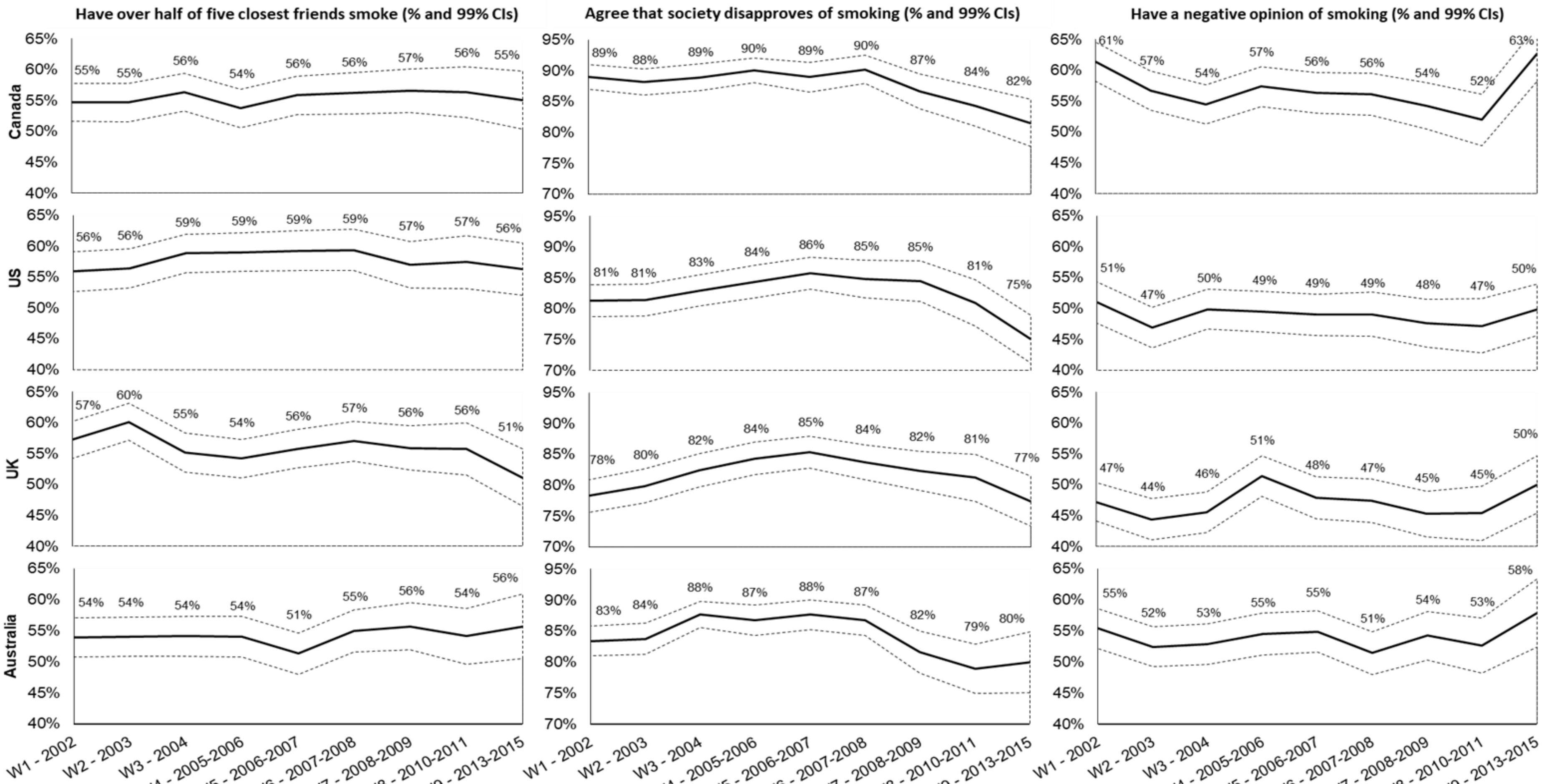
Table A9 continued below.

Table A10 (continued; referred to as Supplementary Table 3 in the publication in Chapter 8). Adjusted associations between all model variables and (i) having over half of five closest friends smoke, (ii) agreeing that people important to you believe you should not smoke, (iii) agreeing that society disapproves of smoking, and (iv) having a negative opinion of smoking, among daily smokers (N=57,086 observations from 23,831 respondents).

	(i) Over half of five closest friends smoke		(ii) Agree that people important to you believe you should not smoke		(iii) Agree that society disapproves of smoking		(iv) Negative opinion of smoking	
	AOR (95% CI)	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**	**AOR (95% CI)**	**p**
Ethnicity								
Minority (ref)	1.00		1.00		1.00		1.00	
Majority	1.02 (0.94-1.11)	.557	0.90 (0.80-1.02)	.115	**1.48 (1.35-1.62)**	**<.001**	0.99 (0.91-1.07)	.817
Income								
Low (ref)	1.00		1.00		1.00		1.00	
Moderate	**0.89 (0.84-0.95)**	**<.001**	**1.25 (1.15-1.37)**	**<.001**	**1.31 (1.21-1.42)**	**<.001**	1.00 (0.94-1.07)	.761
High	**0.69 (0.64-0.73)**	**<.001**	**1.50 (1.36-1.65)**	**<.001**	**1.43 (1.31-1.56)**	**<.001**	**1.07 (1.00-1.15)**	**.028**
No answer	**0.86 (0.78-0.95)**	**.004**	1.04 (0.91-1.20)	.513	0.89 (0.79-1.00)	.072	**0.80 (0.72-0.88)**	**<.001**
Education								
Low (ref)	1.00		1.00		1.00		1.00	
Moderate	**0.81 (0.76-0.86)**	**<.001**	1.01 (0.93-1.10)	.673	**1.10 (1.02-1.19)**	**.007**	**1.18 (1.11-1.25)**	**<.001**
High	**0.57 (0.53-0.62)**	**<.001**	**1.14 (1.02-1.28)**	**.018**	**1.37 (1.23-1.52)**	**<.001**	**1.41 (1.30-1.52)**	**<.001**
No answer	1.08 (0.73-1.62)	.677	0.88 (0.50-1.54)	.664	**0.61 (0.39-0.94)**	**.026**	1.79 (1.12-2.85)	.013
HSI	**1.10 (1.09-1.12)**	**<.001**	**0.94 (0.92-0.96)**	**<.001**	1.01 (0.99-1.03)	.251	**0.96 (0.95-0.98)**	**<.001**
Mode								
Telephone (ref)	1.00		1.00		1.00		1.00	
Internet	1.03 (0.93-1.14)	.556	**0.55 (0.48-0.63)**	**<.001**	**0.63 (0.55-0.72)**	**<.001**	**0.76 (0.69-0.84)**	**<.001**
Time-in-sample	**0.93 (0.91-0.95)**	**<.001**	1.00 (0.98-1.03)	.512	**1.05 (1.02-1.08)**	**<.001**	0.99 (0.97-1.01)	.810
Time-between-Waves	**1.05 (1.00-1.10)**	**.040**	**1.11 (1.04-1.19)**	**.001**	0.95 (0.89-1.02)	.215	**0.94 (0.90-0.99)**	**.018**

HSI=Heaviness of Smoking Index. AOR=Adjusted Odds Ratio, adjusted for all variables in the model. 95% CI=95% confidence interval. 95% CIs are reported to 3 decimal places where they are close to 1.00 (±0.005). Linear, quadratic, and cubic terms for Wave (presented in Table 2 in the manuscript body) are not included here as these terms were added the model as an additional step (see Analyses section).

Figure A1 (referred to as Supplementary Figure 1 in the publication in Chapter 8). Average predicted probabilities of having over half of five closest friends smoke, agreeing that society disapproves of smoking, and having a negative opinion of smoking, by Wave and country (N=57,086 observations from 23,831 respondents)



Average predicted probabilities and 99% confidence intervals (CIs) are generated from the Wave*Country interaction terms in the binary logistic regression analyses, adjusted for age, gender, ethnicity, income, education, heaviness of smoking, survey mode, time in sample, and time between Waves. Data are weighted. 99% CI=99% confidence interval. W=Wave.